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APPLICATION OF ELECTRONIC DATA PROCESSING METHODS IN
EDUCATION.

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THIS REPORT, WHICH PLACES THE USE OF ELECTRONIC DATA
PROCESSING IN EDUCATION IN BOTH FACTUAL AND SPECULATIVE
PERSPECTIVE IS INTENDED FOR THE UNINITIATED EDUCATOR, THE
INTERESTED LAYMAN, AND THE SPECIALIST IN INFORMATION
PROCESSING TO HELP HIM UNDERSTAND CURRENT EDUCATIONAL
PROBLEMS SO THAT HE CAN ASSIST EDUCATORS WITH THE DATA
PROCESSING ASPECTS OF THE PROBLEMS. THE REPORT IS BASED ON A
SEPTEMBER 1963 STUDY WHICH BEGAN AT UCLA'S LAKE ARROWHEAD
CONFERENCE OF SPECIALISTS IN EDUCATIONAL DATA PROCESSING,
CURRICULUM DEVELOPMENT, PSYCHOLOGY, RESEARCH, EDUCATION, AND
ADMINISTRATION. MANY PROMINENT INSTITUTIONS AND ORGANIZATIONS
WERE REPRESENTED. CHAPTER ONE PROVIDES AN OVERVIEW OF VALUES,
FORCES AND TRENDS IN AMERICAN EDUCATION. CHAPTER TWO,
DISCUSSES INFORMATION PROCESSING SYSTEMS IN EDUCATION. AN
ANALYSIS OF PROBLEMS, ISSUES, RECOMMENDATIONS, AND CRITERIA
FOR FUNDING RESEARCH IS PRESENTED IN CHAPTER THREE.
RECOMMENDATIONS AND CONCLUSIONS ARE MADE IN CHAPTER FOUR.
APPENDIXES AND READING LISTS ARE PROVIDED. (JC)

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F-026

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U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
Office of Education

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TABLE OF CONTENTS

	PAGE
FOREWORD	ii
 CHAPTER	
ONE	
EDUCATION AND COMPUTER TECHNOLOGY	1
Computer Applications in the Military,	
Business, Industry and Science	2
Computer Technology and the Changing	
American School	5
Educational Problems Today and Tomorrow	10
 TWO	
ILLUSTRATIVE APPLICATIONS OF COMPUTERS	
AND INFORMATION PROCESSING SYSTEMS IN	
EDUCATION	17
Scope of Present Developments	18
Technical Terms, Facilities, and Equipment	21
Illustrative Applications	22
Summary and Analysis	30
 THREE	
THE LAKE ARROWHEAD CONFERENCE: PROBLEMS,	
ISSUES, RECOMMENDATIONS, AND CRITERIA	33
Problems and Issues	34
Recommendations	37
Criteria for Funding Projects	38
 FOUR	
SUMMARY ANALYSIS: RECOMMENDATIONS AND	
CONCLUSIONS	41
Recommendations	41
In Conclusion	46
 APPENDICES	
A	
LAKE ARROWHEAD COLLOQUY PARTICIPANTS	49
B	
ELECTRONIC DATA PROCESSING IN EDUCATION:	
THE STATE-OF-THE-ART	52
C	
DESCRIPTIONS OF STATE, REGIONAL, AND LOCAL	
EDUCATIONAL DATA PROCESSING PROGRAMS	78
D	
SELECTED BIBLIOGRAPHY	99

FOREWORD

The very words, "electronic data processing," bring visions other than of sugar-plums into the heads of educators. For the uninitiated, these visions are somewhat unsettling, largely because they blur and fade into the great unknown. For the initiated, especially those who have in some ways tied their careers to computers, these visions are both exhilarating and sobering.

The purpose of this report is to steady the focus a little for the uninitiated educator and interested, intelligent layman; in essence, to place electronic data processing in education in both factual and speculative perspective. It is intended for the specialist in information processing only to the extent that some understanding of current educational problems will help him to assist educators with the data processing aspects of these problems.

In September, 1963, the University of California, Los Angeles, received a grant (John I. Goodlad, principal investigator and John Caffrey, co-investigator) to support a study of uses, problems, issues, and promising directions for research and development in electronic data processing in education. The study began at the University's Lake Arrowhead Conference Center with a conference of specialists in educational data processing, teachers, curriculum and guidance specialists, administrators, psychologists, and research workers. The following institutions and organizations were represented: The United States Office of Education, several state departments of education, public and private schools, colleges and universities, the Association for Educational Data Systems, the Council of Chief State School Officers, the California Educational Data Processing Association, the Council for Educational Data Systems, Educational Systems Corporation, Educational Testing Service, the New England Educational Data Systems, the Association for Computing Machinery, Stanford Research Institute, and System Development Corporation.

This conference provided the research team from UCLA and their associated research colleagues from System Development Corporation, Santa Monica, with a vivid background of discourse concerning past, present, and future in the field. Most of those in attendance forwarded position papers in advance of their coming or brought these with them. The papers provided an immediate basis for determining areas of common problems and interests, of disagreements, and of unresolved issues. Several days of discussion revealed some sharply diverging views, as well as some substantial agreement on needs for the future. From the viewpoint of our study team, the opportunity to participate in this conference of persons either already deeply involved with or interested in electronic data processing proved indispensable.

Hopefully, this report will prove useful for the reader to whom the topic has been relatively unfamiliar. More specifically, however, we hope it will serve the needs of those educators and laymen who may be called upon to make decisions regarding the support of research and development proposals in the field: members of research proposal evaluation committees, staffs of government funding agencies, foundation officials, administrators, and legislators. This report is not designed to help the specialist in

EDP who also is knowledgeable in education; nor is it a casebook of practices and methods.

Subsequent pages provide an overview of values, forces, and trends in American education (Chapter One); a discussion of information processing systems in education, with examples of practice (Chapter Two); an analysis of problems, issues, recommendations, and criteria for funding research and development projects emerging at the Lake Arrowhead Colloquy (Chapter Three); and some recommendations and conclusions growing out of preceding chapters (Chapter Four). The Lake Arrowhead experience provided a productive springboard for getting into the problems of automated information processing in education as they are now being encountered in both theory and practice.

The reader who wishes to pursue some of the more technical aspects of electronic data processing in education is referred to Appendix B, Electronic Data Processing: The State of the Art. Appendix C enlarges the list of data processing developments used merely as examples in Chapter Two. The selected readings in Appendix D expand upon some of the topics which could be developed only minimally on preceding pages.

Stanley Rothman of System Development Corporation read the entire manuscript, contributing significantly to content, style, and clarification of technical concepts. Sterling Stott of the University of Washington provided us with a preliminary analysis of the tapes recorded at the Lake Arrowhead Conference. Donald D. Bushnell of the Brooks Foundation helped to design this Conference and assisted with the identification of key projects. Stuart R. Johnson of the University of California, Los Angeles, assisted with administrative details, particularly toward the end of the project, and with production of the report. Miss Rayilyn Brown went far beyond the call of duty in preparing the manuscript and in supervising the various stages of its production.

John I Goodlad and Associates
January, 1965

The great, metallic beast . . .
The genie we have raised to rule the earth,
Obsequious to our will
But servant-master still,
The tireless serf already half a god . . .

- Stephen Vincent Benet

CHAPTER ONE

EDUCATION AND COMPUTER TECHNOLOGY

A precocious infant scarcely out of swaddling clothes has moved relentlessly and inescapably into our lives. The electronic computer, mainstay of an advancing information technology, is significantly altering a wide range of human affairs. Limited mainly by the resourcefulness of its user, the computer is viewed by some as a potentially dynamic force for meeting the rapidly changing needs of society, for eradicating social ills such as poverty, and for freeing all men to engage in pursuits once thought to be the exclusive domain of an elite few. It is viewed by others as a threat to man, to mankind's very existence.

What is this pseudohuman possessing apparently vast potentialities for good or evil, just as man himself possesses these dual propensities? Our first lesson in the computer--one we must never forget--is that the machine first derives its potentialities from man himself.

Picture if you will a room full of specialized clerical workers. The work to be done in "The Room" is inserted through a window marked IN and results emerge from a window marked OUT. The workers in "The Room" are superbly skilled at their highly specialized work, but they are obliged to do no more nor less than what they are told. Any work to be done must be accompanied by detailed instructions, written in a precise language whose small vocabulary consists of terms such as add, subtract, multiply, divide, and compare. The workers in "The Room" make no decisions themselves but operate according to fixed rules. For example, they may compare two words or numbers and determine whether they are identical. The instructions for the problem must specify what is then to be done if the values are equal or unequal. The way in which the results of the work are to be arranged upon emerging from the OUT window must also be specified in advance. If a set of instructions contains erroneous or contradictory rules, or if an unanticipated case occurs, the workers in "The Room" will coldly signal this fact, cease their work, and throw the whole job through the OUT window. The workers never tire, they never make a mistake, and they perform each step of the work in a few millionths of a second. They can be instructed to store almost any quantity of information needed for reference, and they can type out results of their work very neatly at the rate of several hundred lines per minute. They can serve several customers simultaneously, by special arrangement, without ever being confused or irritated. If "The Room" can be imagined as the inside of an intricate electronic device, and if the "workers" can be visualized as its components, and if it is also understood that every statement which begins with the word "never" is wrong, the reader has now been introduced to a thinly disguised notion of what a high-speed electronic digital computer can do.

The computer is the heart of electronic data processing and EDP (this abbreviation will be used frequently) in turn is now viewed by our most insightful educational leaders as a necessary tool in advancing theory, research, and practice in education. This report inquires into the present status of EDP in education, explores some of the

problems and issues involved, and formulates recommendations for research and development. The focus is on elementary and secondary schools; only occasional reference to higher education occurs. First, let us take a quick look at the use of computer technology in other human endeavors.

COMPUTER APPLICATIONS IN THE MILITARY, BUSINESS, INDUSTRY, AND SCIENCE

Acceptance of the high-speed digital computer, unlike many other great technical achievements, has been remarkably favorable, especially in national defense, in business and industry, and in science. In 1964 over four billion dollars were budgeted for procurement of computer equipment and an additional two billion for programming and related software aspects of this equipment. There were at least 16,000 major computer installations in the nation during that year and 7,000 more on order. Approximately 1,250 of these were in use by the federal government (including the Defense Department and the Atomic Energy Commission), compared with 730 as recently as 1961. No doubt, all of these figures will appear puny a decade from now.

In the military, computers with their associated information processing systems are essential to all space activities and to modern electronic warfare and are becoming an important tool for developing national defense strategy. Only a computer can calculate swiftly enough to analyze the data from a satellite or to provide flight guidance for a rocket. Computer-centered command and control systems enable commanders to deploy strategic bombers, launch missiles, and provide early warning of an impending enemy attack. The global logistics and inventory systems of the armed forces could not function without computers. The resulting human responsibility for telling the machines the "right" things and technical responsibility for fool-proof response are at once frightening and overwhelming.

In industry, computer technology has had a tremendous impact on the improvement of production methods and on the science of management. Modern chemical plants and petroleum refineries are controlled by computers. In banks, insurance companies, large department stores, and most corporations which require large amounts of record-keeping, the computer has eliminated repetitive tasks and saved millions of dollars by company-wide integration of such functions as purchasing, inventory control, and scheduling.

Computer technology is exerting its influence in the scientific community. Scholar working in physics, optics, chemistry, engineering, psychology, economics, and other fields are using sophisticated computer analysis in research programs which, in turn, often produce totally new techniques and achievements. Even the humanist, for whom the machine must often be an anathema, sees in it possibilities for enhancing his research.

Before World War II, the only digital computers in use were analogue computers, desk calculators, or very slow, mechanical, switchbased computers. Military demonstrations of computer versatility and the scientific requirements of the space age have accelerated the growth of the computer industry. Following World War II, electronic computers were built at several centers, including Princeton, MIT, the University of

Pennsylvania, and the RAND Corporation. In 1951, the U. S. Census Bureau demonstrated the tremendous contribution of a computer to government efficiency. In the middle 1950's, with the development of reliable high-speed computer memories, large and economically feasible computers began to appear in great numbers. Since then, computers have evolved from relatively small and slow equipment to large machines with very fast memory (millionths of a second) and to sophisticated information input and output equipment able to perform many operations at reasonable cost. The unit cost of computation has decreased by a factor of at least ten with each succeeding generation of computers.

Today, most computer installations operate in the plants and offices of several thousand corporations where they have yet to be employed in tasks which approach the full power of the instruments. Applications to date tend to arise out of specific problems which are considered most pressing to management. The computer is being used largely to automate business functions and procedures which previously were done by manual methods, the machine being programmed to perform existing practices. Usually, it is relatively easy to rationalize the cost of repetitive operations now being conducted by large numbers of clerical workers. Routine data processing involves preparing payrolls, recording and sorting bank checks, billing, analyzing personnel and financial data, and performing a wide variety of calculations.

But now that the practicality of routine business applications has been demonstrated, more and more corporations are moving toward broader uses of computer technology. As a consequence of automating even a routine record-keeping process, the functions of an organization may change substantially. It may prove uneconomical to do only the present work when the computer system can yield much more. The information being processed may be found to have convenient additional and parallel uses. Sometimes, new practices emerge to transcend previous ones. Computerization of a business function improves understanding of the process and reveals better ways for a corporation to conduct its operations, increasing the likelihood of consolidating and integrating various functions. The computer also can yield entirely new types of information which will stimulate the development of new conceptual patterns within which to carry on business activity. Finally, computer systems have now been developed which are used as the central part of a communication network involving a number of widely dispersed elements of a business enterprise. Centralization of control and more effective management are facilitated since events are reported as they happen. It seems likely that future computer applications will move beyond mere substitution of automation for the present manual activities of a business or industrial organization.

What benefits already have been achieved through the use of computer technology? Besides the obvious cost savings resulting from increased productivity, several major contributions are beginning to emerge. A characteristic of the computer, unique among technical achievements, is that anticipated installation has forced users to think more precisely about what they want to do. Objectives must be carefully analyzed and specified in exact terms before the computer can be programmed.

Another value lies in the increased capability acquired by business managers. More rapid and accurate assessment of complex environmental data permits better understanding of changing relationships among data so that circumstances can be controlled as they are developing. The computer also can help industrial executives by

simulation techniques: prediction of the results of policy changes by using models of the enterprise based on past experience. Part or all of some business and industrial operations, as well as complex social systems, can now be simulated in a computer for investigating decision-making processes. These techniques increasingly have been applied to management problems. One simulation program, using a minute of computer time, has been able to represent abstractly the operation of an entire business over a period of 400 weeks. The company's operating data are fed into the computer which evaluates several alternatives for decisions about finance, personnel, product scheduling, and other operating variables. From these alternatives, management chooses the most effective one from established criteria. But, of course, men must formulate the criteria and the alternatives.

Probably the most important potential benefit which computer technology can offer is assistance in making better management decisions. By providing timely, relevant, and accurate facts, managers can rely less on intuition and more on systematic analysis, and thus use their time and imagination more creatively. Long-range planning, the development of new products, and the formulation of improved financial and public relations policies now come in for more attention.

The utility of the computer and its associated data processing systems depends on the ingenuity of the user. At present, a universally accepted taxonomy of computer usage simply does not exist. But, clearly, the most successful users have been those on the alert for new possibilities, even while the machines were employed profitably on routine tasks. Nonetheless, the future in most fields now being computerized, if sketched in by the few men most qualified to envision it, undoubtedly would be scarcely recognized by today's most forward-looking executives.

Uncertainty about the future and mystery surrounding the computer itself have bred a measure of stress and insecurity, especially among mid-career personnel. What, specifically, does it mean for me? Am I soon to be replaced? And not by flesh-and blood competitors I can understand, but by incomprehensible, inscrutable antagonists of seemingly limitless, indefatigable power. The need to clarify the intent of my present functions for computer programming may reveal their long-overlooked obsolescence. Must I embark on a period of re-training and will I be able to measure up?

Even the poetic visions of a workless tomorrow with all sharing in electronically-produced abundance is not necessarily everyone's Bali Ha'i. The recent upswing in "moonlighting" among workers is not fully explained by desire for more money. Time on our hands can mean trouble on our hands--psychological trouble--and so shortened hours compel us into a second job. Some of us are so shackled to a work ethic that we simply cannot equate what we have chosen to label work with other challenging pursuits which hitherto have been identified as leisure.

But these may not be the problems of rising generations, growing up with and assuming as their birthright what will then be a mechanized legacy. The demands of their future probably will call for a different kind of education than we have in general today. What should be the form and substance of this education? Will educators, especially those already embarked on their careers, be able to grasp the possibilities of this future and mould schools appropriate to the challenge? And what will be the role of electronic data-processing in these schools? Such questions loom large in an uncertain future.

COMPUTER TECHNOLOGY AND THE CHANGING AMERICAN SCHOOL

Next to national defense, education is the largest single enterprise in the United States. In 1964, expenditures for all levels of public education, including capital outlay, reached approximately 27 billion dollars. The nation's schools and colleges enrolled one-fourth of our population. With millions of people and billions of dollars to be accounted for, the American educational enterprise appears ripe for what computers can so uniquely do.

Information problems are woven all through the fabric of educational processes, from problems of collecting, storing, communicating, retrieving, and displaying information, to problems of receiving, learning, and using information. Teacher, administrator, research and guidance worker, business manager, board member--all are very directly concerned with transmission and utilization of information. Information is grist for computers.

National attention is now focused on the strategic importance of education. At home, there are problems of economic growth, prejudice and racial unrest, even poverty and unemployment; abroad, a dozen hot-spots call for never-ending vigilance; beyond, outer space beckons us. Our educational institutions are expected to produce personnel capable of meeting our myriad exigencies today and tomorrow and, somehow, of leading the way to a better, calmer way of life lying beyond. The past decade has witnessed pressure on our schools of a kind and intensity not experienced before. It is the nature of American schools to respond to a variety of appeals--and respond they have with a host of changes, both peripheral and fundamental. Let us examine, briefly, some of the forces thrusting in upon American education, some of the values underlying it, and some of the responses of a changing school.

Values and Forces

American education is guided by at least the following ideals: education is for all Americans; education is designed to develop individuals to their full potential; education enables the individual to act more intelligently; education contributes to the solution of virtually all social problems; education can never come too late; education opens up the largest number of roads to the good life. These ideals never go unquestioned but they survive and, in fact, appear to strengthen their appeal in the face of adversity. The armor of those who war against them shines brightly for only brief interludes.

We probably expect too much of education; certainly, we expect too much of formal schooling. Schooling does not guarantee rationality, nor virtue, nor goodwill toward neighbors, even in those who partake of it extensively. Education does not by itself solve economic problems, remove racial inequalities, or ease world tensions. But education prepares the ground, we think, for enlightened human action.

As education in America has expanded quantitatively, the concept of education for all has become more inclusive and is increasingly compounded by our expanding insight into the startling, challenging realities of individual differences. Education for all includes the average, the gifted, the mentally retarded, the emotionally and physically handicapped, and now the environmentally disadvantaged. Just as soon as neglect of

some specific group is identified, immediate concern is evidenced and proposals are developed to take care of this group. Just as it is important to develop all Americans, so is it important to develop all of their abilities. When science and mathematics were at last receiving their due attention, ears were turned to the appeals for art and music. Educators have no one-sided concern about the individual. Nor have they fixed time-limits for education. Programs for foreign-speaking citizens-to-be, easy admission from one level of education to another, and gargantuan provisions for adult education are all examples.

With these ideals before them, schools must be particularly responsive to exploding knowledge, science and technology, urbanization, population growth; to the very cry for more and better education; to new insights into those who are to be educated; and to increased understanding of education itself. The responses have not yet been adequate, especially for our social ills; they probably never will be. But some of them are imaginative and impressive.¹

Curriculum Reform

A massive curriculum reform movement is underway in response to international tensions and competition in space, the knowledge explosion, general dissatisfaction with school programs of the 1930's and 1940's, and various other interacting forces. There are now many new configurations in the alphabet soup of educational groups and organizations: BSCS (Biological Sciences Curriculum Study), CHEMS (Chemical Education Materials Study), MSG (School Mathematics Study Group), PSSC (Physical Science Study Committee), and so on. Each of these groups--and many more--has produced an instructional materials package comprising textbook, supplementary reading material, workbooks, laboratory experiments and manuals, teachers manuals, films, and filmstrips.

Back of this package exists an assumption pertaining to how the curriculum should be organized, brought into being for the reason, probably above all others, that expansion in knowledge has far outstripped the capacity of men to encompass it. Schwab² has stated the knowledge problem dramatically:

"At the present tempo of research in the western world, I would estimate the duration of a revisionary cycle in a median science to be on the order of fifteen years. Thus a body of knowledge acquired in the conventional way by a graduate of 1960 is likely to be largely inadequate by 1968 and, by 1975, as obsolete as notions of body humours, the ether, or the impenetrable atom."

If the "conventional way" of acquiring knowledge no longer suffices, new ways must be found. The curricular assumption, clearly evident in new mathematics and sciences curricula (which more than others were spawned by new knowledge) is that acquisition is best facilitated when learnings are arranged so as to emphasize basic concepts, fundamental principles, and key modes of inquiry comprising the "structure" of the field.³

The approach calls for identifying these fundamental organizing elements and arranging curricular specifics in the most meaningful sequences. To date, a trial-and-error process of checking and adjusting to student responses has predominated, with the computer playing a role only in a very few projects which have proceeded more systematically. So far, the current curriculum reform movement, in general, is simply an implementation of important but largely untested assumptions. But, when programs seek experimentally to relate individual patterns of concept formation and subject-matter modules assumed to be logically derived, electronic data processing techniques should prove indispensable.

Programmed Instruction

Closely aligned with certain assumptions underlying present curriculum reform, on one hand, and computer technology, on the other, is the advent of programmed instruction. The demands of programming force the programmer to come rigorously to terms with his subject-matter and to be precise about the changes he is trying to induce in his students. According to Skinner,⁴ the student, in turn, becomes actively involved in the instructional as well as the learning process.

Programmed instruction is in part a response to the challenge of providing for individual differences among learners. Should large numbers of good programs ever become available--and, currently, the lack of them and the difficulty of writing good ones together constitute a formidable bottleneck--students will be able to work successfully and competently on their own for portions of their time, to select courses which would not otherwise be available, to make up missed work, and to strengthen diagnosed weaknesses. According to one theory, programmed instruction minimizes or even eliminates differences among students pertaining to their actual ability to progress through a planned sequence: "If the learning program is successful, it insures positive transfer from lower to higher level learning sets for each individual learner, and thereby reduces individual differences in achievement of all subordinate learning sets in the hierarchy."⁵ Presumably, then, when students become derailed, there are gaps in the sequence which should be filled with more subordinate learning sets. By carefully observing student performance, the programmer systematically refines the sequence until it is virtually foolproof. This theory raises questions of more than passing significance about the kinds of human learning which can be reduced to programmed sequences.

The systematic refinement of programs is of particular relevance in any discussion of EDP. Scanning the performance feedbacks of even small numbers of students on relatively short programs is a formidable task. But, when the size of the population is increased and diversified to include adequate samples of both sexes, varying levels of tested intelligence, differing past performances, and a range of socio-economic groups, this task quickly expands to astronomical proportions. Again, enter the ubiquitous computer, "The tireless serf already half a god. . ."

The computer promises powers of observation in curriculum and instruction which may prove useful in theory-building, since controlled observation plays so significant a role both in formulating and in testing hypotheses. To date, our theories of instruction have been less than adequate, to say the least, and our theories of curriculum have been virtually non-existent. Programmed teaching machines, in turn linked to computers, may prove to be useful tools in fashioning more productive theoretical formulations.

School Organization

During the past decade, the graded structure and the teacher-per-class-per-grade organization of America's schools have been significantly modified. The relative success of recent attempts at modification, in direct contrast to earlier efforts, probably is due in large part to the viability of the alternatives proposed and being implemented. And, of course, we must never forget that these proposals have emerged in an era that demands alternatives. At other times, nongraded schools and team teaching ventures might well have joined their predecessors--many of them close cousins--in history's vaults.

Nongrading sweeps away the graded superstructure, graded content, graded textbooks, graded normative standards, graded children, graded teachers, graded expectations, and graded nomenclature to which we have long been accustomed. It is the fact that we have been so long accustomed to these accoutrements of graded schools that we fear and resist their departure. For them, nongrading substitutes continuous pupil progress uninhibited by grade barriers; subject-matter organized sequentially around fundamental concepts, principles, and generalizations; instructional materials gathered together for the task at hand and the varying abilities of the learners involved with it; criterion performance standards inherent in the learning task itself (excellence is determined from actual performance, not comparisons with others); alternative classroom placements for learners based on pupil diagnoses; individual expectations for students; and still other provisions.

Team teaching casts aside the traditional, teacher-per-grade-per-subject concept of teacher use, together with our monolithic deployment of teaching talent. Instead of 30 pupils in a self-contained classroom with one teacher for all subjects, or in a departmentalized plan with a single teacher and one subject, visualize 75 or 100 or 150 students supervised by a team of teachers and teacher aides, deployed into instructional groups of various sizes, and space provisions appropriate to these groups. The teaching team functions under a leader and delineates staff functions according to the needs of students, abilities of teaching personnel, and demands of the tasks. A considerable portion of time goes to pupil diagnosis, counseling, and scheduling.

Many schools in the United States carry the nongraded label.⁶ But none has fully achieved what has been envisioned for nongrading. Similarly, team teaching and various modified cooperative teaching plans are well enough established in theory and practice to have spawned a sizeable body of publications.⁷ But visions of what might be intoxicate the brain while practice lags far behind. The gulf between what exists and what might be is largely due to the need for reform in all those educational phenomena on which nongrading and team teaching depend: curriculum, materials, testing, teacher education, and information processing. And implementation of reform in these phenomena awaits the creation of flexible school structures such as nongrading and team teaching. Innovation occurs on a broken front but, for the full possibilities of innovations to be seen and acted upon, education must be viewed all of a piece.

One way of viewing the consequences of inter-related decisions before they are made is to simulate a variety of possible answers--in essence, to anticipate and imitate the operation of a school or school system into which certain changes have been or are to be introduced. The variables and the possible relationships among them are too many to be manipulated manually or in the mind of one person. The computer

clearly has demonstrated imitative propensities in other fields, particularly commercial airline activities and missiles programs, and increasingly is entering into the simulation of educational maneuvers.

Removing the structure--such as fifth, ninth, and eleventh grades--which largely dictates certain decisions about students imposes increased responsibility upon teachers. Expanding the range of learning opportunities available to students--as in team teaching, for example--also creates new teaching demands. Teachers must now diagnose each student, determine the best possible class placement, and subsequently relate student abilities and program in a productive pattern. Suddenly, there is urgent need for new information, not days or weeks from now but here at the time and place of decision-making. Subsequently, the effects of these decisions must be observed and recorded. We have scarcely begun to realize the problem, let alone to conceptualize the data needed and to devise ways of obtaining them. Undoubtedly, the computer will be central to our solutions.

Materials

School principals report that what publishers produce for school use, particularly textbooks, is the most powerful determinant of what students actually study.⁸ Staffs of the various curriculum reform projects are very sensitive to the materials product; most of the \$15 millions in annual National Science Foundation support goes into materials preparation and production. Every conceivable audio-visual approach to the learning senses is employed.

A quiet revolution in the organization and use of instructional materials is taking place. In the past (and still today) energetic teachers wrote, telephoned, travelled, begged, borrowed, and probably stole in their zeal to assemble a wide assortment calculated to titillate the interest of even the most incorrigible ten o'clock scholars. One teacher education course at a well-known university was built around the preparation of a bottomless box of burgeoning goodies. Tired teachers, however, contented themselves with textbooks and workbooks--and perhaps a film on Friday afternoon. Goodness knows, the school library, if one existed, didn't offer much.

The teaching Utopia is to be able to "call up" at will photograph, painting, book, pamphlet, object, film, filmstrip, record, or even living instructional resource. Enlightened librarians plan and function with this ideal in mind. The classroom comes into the library and the library goes into the classroom. In some new physical plants, where one begins and the other ends is scarcely distinguishable visually; other new buildings often are planned around the library, with special attention to the to-and-from flow of the student body. What appears to be of central significance in students' learning has at last become central in at least some educational planning.

This concept of materials use and organization--the most appropriate item for the task at hand and a controlling pattern for all the items--suggests electronic data processing systems. In a vast and complex system, there are millions of items and countless combinations for assembling them. Even in relatively small systems, the possible combinations and permutations stagger the imagination. Manual processing techniques simply cannot do the job.

The Education of Teachers

Computer technology potentially enters into the education of teachers in two major ways: first, in the management of the teacher education enterprise; second, in the education of personnel who at least grasp the significance of electronic data processing for improving the educational enterprise. Regarding the first, the changing character of American education has brought about a need for specialized personnel of many kinds. Team teaching in elementary schools has created a demand for subject-matter specialists at that level; nongrading requires personnel skilled in pupil diagnosis; programmed instruction requires programmers; greater emphasis on individualized programs creates demand for counselors; systematic approaches to the use of materials necessitate persons capable of bringing programs and materials together. These demands rule out conventional "mass" approaches to the preparation of teachers.

Further, young people entering teacher education curriculums today come from diverse backgrounds of previous education and experience. Many have worked as camp counselors, as assistants in cooperative nursery schools, and as hospital volunteers; and now comes the ex-Peace Corps group. To run these future teachers through a production mill is to do violence to their individuality and to deprive the schools of special talents which might be honed through individualized teacher education techniques. The problem is to bring background, interest, goal, and selected curricular activities into effective juxtaposition so that the needs of the individual and the needs of the schools are met simultaneously. Teachers of teachers must devise the conceptual schemes; computers stand ready to process the data.

Regarding the second potential of EDP in teacher education, there is now a knowledge gap between conceptions of schooling and computer science. Since schoolmen do not understand the computer and what it might be able to do for them, they think in manual data processing terms. They scarcely dream of what might be facilitated were EDP techniques introduced. The computer scientist, in turn, is not sufficiently aware of school problems to see beyond using EDP for relatively routine tasks. Into this knowledge gap must step educators who can think productively of an educational future in which the computer serves appropriately. We speak to the preparation of such persons in later chapters.

EDUCATIONAL PROBLEMS TODAY AND TOMORROW

The continued use of antiquated information processing procedures in the face of the growing size and complexity of American education constitutes a gross anachronism. Education is in large measure an information processing system. The right data at the right moment give teachers and administrators the edge they need for making calculated rather than uninformed decisions. Wisdom and information are a powerful team. Computers can provide the information; educators must provide the wisdom. We have seen that American education today involves billions of dollars and millions of people, changing curricula, new patterns of school organization, more effective means of supplying and using materials, and diverse decisions of instruction and of administration. The problems range from counting things and people to matching things and people; from studying things and people to simulating relationships among things and people; from making decisions about things and people to innovating with things and people; from our

concern over deliberately controlling things and people to speculating about things and people. Electronic data processing plays a potentially powerful but presently too neglected role in all of these.

We have seen, too, that the uses and potential uses of EDP in education range from relatively simple but quantitatively significant tasks of storing and retrieving masses of raw data to tasks calling for involved decisions and research. Table 1 depicts this range of tasks for which electronic data processing procedures might be appropriate. In the left-hand column are five realms of educational activity; across the top are three levels of conceptual complexity. Level 1 calls for the processing of large quantities of data; level 2 for pulling out relationships among categories of data; level 3 for formulating research designs and making major decisions. Setting up the data processing system demands, presumably, higher level cognition at level 3 than at level 1. The categories on either axis could be extended and arranged differently; they serve simply to conceptualize a range of possible uses for EDP in education.

The educational activities listed under level 1 parallel a long list of activities in business, industry, and the military which are now commonly being managed by computers. Consequently, there are few new problems here in seeking to apply EDP techniques in the field of education. Similarly, the processes implied under level 2 are now routine in many enterprises. There are far fewer models for level 3 tasks and so we can anticipate the emergence of new approaches, some of which will contribute to fields other than education, as educators make use of EDP in coping with this category.

Level 2 reveals a rather interesting phenomenon. Thousands of theses, dissertations and research studies in education and psychology concern themselves almost exclusively with patterns of relationships: between socio-economic factors and success in schools, between students' and teachers' values, between creativity and intelligence, between school system salaries and teachers' mobility, and on and on. Such studies often involve careful selection of criteria and preparation of instruments. In the past, they also have involved painstaking hand checking of tests of significance. These statistical analyses, formerly requiring months of such labor, can now be processed in minutes of computer time. Of even greater significance, however, hundreds of possible inter-relationships among data--each one of which might well have been viewed as adequate and appropriate for a master's thesis a few years ago--can now be explored in equally brief periods of time.

This capability of the computer points to the conclusion that an entire class of research studies formerly considered fair game for the graduate student simply are not worth his time. It is questionable that they ever challenged the intellect appropriately but the answers required tedious work and graduate students were ready slaves. The dangers are in equating such efforts with scholarship and in condoning countless hours of hand processing data because of our allegiance to the work ethic.

Graduate schools must now involve their students in research studies requiring higher level conceptualization to be certain both that human talent is appropriately challenged and that problems of significance become better understood. Very often, analyses of relationships among data will be conducted, with the computer performing the labor, as routine preparation for research requiring entirely new conceptions of hypothesized relationships. This, more often than not, will be team research, involving professors as principal investigators assisted by graduate students with both co-

TABLE 1
PROBLEMS IN EDUCATION APPROPRIATE FOR ELECTRONIC DATA PROCESSING

	Level 1 Raw Data	Level 2 Relationships Among Data	Level 3 Decisions and Research
General Policy and Administration	Codification and systemization of school laws, sources of funds, health and safety regulations, etc.	Effect of new policies on school health and safety records.	Studies into the relationship between policies and teacher and student effectiveness.
	Results of polls on citizens' expectations for their schools.	Patterns of relationships among sub-publics and types of expectations for schools.	
		Relationships among types of administrative problems and processes used in decision-making.	Conceptualization of possible new relationships and simulation of the consequences of effecting these relationships administratively.
Faculty, Staff and Students	Comprehensive inventories of teacher and pupil background.	Relationships among factors such as age, institution attended, credential, etc., and teacher retention in the system.	
	Long-term collections of data on student achievement, attendance, health, dropout, etc.	Relationship between factors in school achievement and factors in students' health.	Prediction of students' success in school from longitudinal data, followed by deliberate manipulation of the environment and analysis of the consequences.

TABLE 1 (Cont'd)

	Level 1 Raw Data	Level 2 Relationships Among Data	Level 3 Decisions and Research
Budget and Financial Support	Statistics on school costs broken down into budgeted categories.		
	Maintenance of assessed evaluation statistics and data pertaining to proportion of district's income going to education.	Relationship between financial support and various evidences of school productivity.	Decisions pertaining to school bond elections and building construction in relation to alternative predictions of population growth and financial support, together with calculations pertaining to how much new industry will be attracted by new and better schools.
Facilities	Cost statistics on all aspects of school construction and maintenance.	Relationship between costs of various types of construction and costs of maintenance.	Manipulation of facilities to test hypotheses growing out of observations at Level 2.

TABLE 1 (Cont'd)

	Level 1 Raw Data	Level 2 Relationships Among Data	Level 3 Decisions and Research
Curriculum, Instruction, and Materials	Numbers of students in various patterns of curriculum	Relationships between students' high school curricula and later academic and work careers.	
	Students' responses on programmed lessons and courses.	Relationship between responses and age, I.Q., past achievement, etc.	Studies into students' learning styles and various provisions for them such as different sizes and types of groups.
	Storage and retrieval of data on students' assignments to individual instruction, large groups, small groups, etc.	Relationship between students' assignments and various aspects of students' success.	Manipulation of the instructional-grouping environment to test hypotheses growing out of observations at level 2.

operative and individual functions to perform. Hopefully, students from such programs who ultimately join the academic ranks will stimulate more significant educational research than we have witnessed in the past.

This analysis of the research category could be extended to all aspects of Table 1. Such an analysis would reveal that the educational enterprise stands to profit enormously from more efficient information processing of the type that already is affecting business, industry, science, and the military. The problems involved appear not to be unique, especially at levels 1 and 2. In all realms of human endeavor, the challenge is to relate automation effectively to the purposes of man, not to subvert the purposes of man for the sake of automation.

To assign top priority to education--from nursery school to the grave--as the means of preventing human disasters, is to express once again the characteristically American confidence, perhaps over-confidence, in education. In any case, to perform effectively the roles so often assigned to it, education must become more efficient. We turn, therefore, to analysis of present applications of computers and to information processing systems in education with the hope of shedding further light on what is required for the future.

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CHAPTER TWO

ILLUSTRATIVE APPLICATIONS OF COMPUTERS AND INFORMATION PROCESSING SYSTEMS IN EDUCATION

The use of computers and electronic data processing procedures in public education is a relatively recent development. In comparison with rapidly expanding applications in business, science, and government, computer technology in education has lagged far behind. Surveys indicate that approximately 300 of the 2,100 colleges and universities, and about the same number of the 33,000 public school districts in the United States now own, rent, or use electronic accounting machines (EAM) or computers.

At the present time, although interest among educators and applications in schools are increasing rapidly, the computer sciences have had only limited impact on education. Automated school information systems are being developed at an ever-increasing rate, but they must be regarded as the exception rather than the rule. Most educators still use relatively primitive techniques for processing the wide variety of information required in the daily operation of schools. Using paper, pencil, and typewriter, they produce a vast number and variety of records and reports which pertain to students, teachers, budgets, and accounting transactions. Endless hours and professional energies are consumed in routine clerical work. Some attention is now being given to other computer applications: those involving instruction, research, school administration, guidance, and related elements of the educational program. However, these are so limited in number that they must be considered as innovative and experimental.

Why is this so? What factors are involved in the comparatively slow growth of computer applications in education? Some of the reasons are psychological and are similar to those found in early applications to business and industry. Many educational practitioners do not relish the prospects of automation in education, just as a significant number of business and industrial personnel did not and, frequently, still do not. It is the unknown world of the computer sciences that tends to threaten their security, as we have seen in Chapter One.

In education, however, there are inhibiting factors which seem not to have affected other enterprises to the same degree. Education is first and foremost an activity conducted by and for humans. Further, it has professional aspirations. Connotations surrounding "human" and "professional" are such that automation of any part of the enterprise appears somehow to be degrading and suspiciously dehumanizing. This is, of course, to overlook the mass of routine to be taken care of in anything so large and complex and the potentially humanizing effects of easing this burden through automation.

There are economic deterrents, too. Educators are faced with the realistic problem of maintaining modern educational programs on fairly constant incomes in relation to the number of pupils served. Limited school budgets are already stretched just to keep pace with constantly increasing pupil enrollments. It is extremely difficult to justify large expenditures of money for new computer or EAM equipment unless significant cost savings and increases in efficiency can be readily demonstrated. Pressures for purchase of language laboratory equipment, audio-visual materials, or other well-accepted instructional devices, for new building programs, and for annual

increases in faculty salaries tend to have priority in school budgets and serve to crowd out exploratory programs involving electronic data processing applications.

There is also a serious lack of knowledge on the part of educators about the power and potential of computer systems for improving educational programs. Probably the most important reason for the slow diffusion of computer applications in education can be attributed to the lack of widespread dissemination of results already achieved by successful data processing installations. School personnel, in general, do not know what computers and data processing systems can do for them. However, from the experience gained in military, business, and science fields, it seems likely that growth in understanding and increased knowledge of existing installations soon will break down resistance in education. Utilization will then increase rapidly.

This chapter first examines the scope of present applications and then moves to description of selected, representative programs. This brief, illustrative list is expanded multifold in Appendix C. The chapter concludes with a list of problems in and obstacles to further development of computer systems in education.

SCOPE OF PRESENT DEVELOPMENTS

Significant pioneering work in applying electronic data processing procedures to school problems is underway. Current estimates suggest that, very soon, many school districts will regard the use of EDP as an integral part of their information processing systems. The significant questions among those who already have experienced the benefits of automated systems in education pertain not to whether electronic data processing methods are to be used but, rather, to when, where, and how they are to be used most effectively.

Compelling forces at work in and on education today are precipitating the predicted growth of electronic data processing in schools. Foremost among these are seemingly never-ending expansion in enrollment and never-adequate supplies of qualified instructional personnel. Administrators are looking to EDP for the release of teachers from wasteful clerical and routine accounting duties. The very existence of this quantitative reality spotlights the potentiality of automation. And so many different groups want data: taxpayers, newspapers, school boards, state departments of education, the United States Office of Education, legislators, researchers. For each of millions of students, hundreds of items pertaining to health, achievement, attendance, interests, and abilities are generated, processed, recorded, copied, filed, evaluated, and indexed. Information formerly not even gathered is now deemed essential for planning curricula, evaluating instruction, counseling students, and administering schools.

Public pressures for increased productivity, school cost reductions, and greater efficiency in education in the space age are factors conducive to growth in EDP. The pace of technological progress and information growth will continue rather than diminish. Education must be responsive to the world environment in which it operates and to which it contributes. If schools are to provide graduates who are attuned to the society in which they live, much more emphasis must be placed on efficiency and quality in the educational process. Data processing methods promise to provide these

attributes. If present developments in computer technology continue to grow and expand in scope, there is every reason to assume that significant improvements in educational productivity will result.

We have seen in Chapter One that a host of recent changes in American education places new demands on information processing. For the improvement of curricula, rapid feedback from trial use with thousands of students is essential. For the refinements of nongrading and team teaching, data pertaining to pupil diagnoses are required. For efficient instructional use of diversified materials, automated cataloging and retrieving systems are mandatory. These innovations call for computers; computers in turn facilitate such innovations.

The expansion of data processing applications in education is being significantly enhanced by active leadership from educational groups having a professional interest in computer systems. The Association for Educational Data Systems, a new professional organization, through its publications and conventions, is beginning to accumulate and disseminate the knowledge necessary to help schools introduce and improve data processing operations. A number of publications now exist. The Educational Systems Corporation, a non-profit organization, publishes the Educational Data Processing Newsletter, the Journal of Educational Data Processing, and a series of monographs. The National Science Teachers Association is sponsoring a Project on Information Processing (PIP) and publishes the PIP Newsletter, which covers the instructional uses of computers in science and mathematics. A new publication, Computer Education Forum, is expected to come into existence soon and will be distributed on a controlled circulation basis.

California, Texas, Florida, Colorado, among states, have educational data processing associations and their programs have been underway for several years. The American Association of School Administrators and the National Council on Measurement in Education, both of which have had regular sessions on data processing at their conventions, also are promoting the cause. The National Education Association has a Technological Development Project under the Department of Audio-Visual Instruction which has produced literature on school information systems and computer-based instructional systems. The Computer Oriented Mathematics Project of the National Council of Teachers of Mathematics is actively exploring the role of computers in secondary school mathematics.

The United States Office of Education has been active in encouraging the utilization of modern educational data processing under several titles of the National Defense Education Act of 1958 and the Cooperative Research Program. From 1959 to 1963, under Title X of the NDEA, the Federal government responded to requests from state education agencies with grants of more than five million dollars to be used on a matching basis for the improvement of statistical services in these agencies. The funds have facilitated significant growth in the use of automated data processing at the state level. Of the 55 states and territories covered by the National Defense Education Act, only 13 were making use of electronic data processing equipment in September, 1958, whereas 51 of these education agencies were using such equipment in 1964.

Electronic data processing methods now enter into a considerable range of activities. Well-designed, tested, and practical means exist for processing the usual

data associated with business: budgets, payroll, accounts payable and receivable, ledger accounts, property management and inventory, and tax rolls and assessments. In addition, a growing number of schools use EDP to handle pupil personnel data: census, registration, schedules, progress reports, transcripts, grade-point averages and rank-in-class, ability sectioning, medical and dental records, physical fitness and disability records, and test results. Employee personnel records are processed by EDP methods in many school systems. In a few states, teacher certification procedures are similarly processed. Research work is materially assisted by automatic processing, and the existence of machine records in many areas of school operation makes possible more economical and consistent evaluation, or even prediction, of the effects of educational policies and procedures.

EDP methods have been used by state and regional associations and governmental units for a variety of management purposes. In one instance, legal opinions regarding school law are indexed on punched cards for easy cataloguing and distribution, saving thousands of dollars in legal fees and obviating delays. In another, test answer sheets are processed for dozens of school districts too small to have their own EDP equipment; computers are used for scoring tests as well as for processing the results of testing. In one state, computers are used to make substantial improvements in the efficiency of school bus routing. In state education agencies, accounting procedures affecting local districts are now performed in minutes rather than weeks, with resulting savings in time and cost, and with the added dividend of permitting the comparison of varying solutions by examining the results of alternative approaches and policies. One onerous task faced by thousands of schools is the assignment of pupils to sections according to a master schedule; practical procedures now exist which mechanize all or substantial parts of these procedures.

A wide range of applications may be found in local school districts, both large and small; in state EDP programs; and in regional projects which serve several states. There seem to be no consistent patterns of use on the basis of size, geographic location, or type of application. In addition, the kind and quantity of equipment used and the practices employed in such use vary widely. Local school districts employ equipment ranging from a simple basic installation of electronic accounting machines (EAM) renting for approximately \$350 per month, to small computer systems renting for approximately \$4,000 per month. Often there appears to be little relation between the size of the district and the sophistication of the equipment used. Some relatively small districts are using one or more computers in a wide variety of applications, while some large districts are still using EAM equipment. Many districts begin by using a service bureau and the progress to their own installations as they gain experience and add different applications and services to those initially supplied by the data processing equipment.

There appears to be one characteristic common to most computer applications in schools today: they are an outgrowth of specific school information handling problems which are considered most pressing to school officials. The computer and EAM equipment are being used primarily to automate business and personnel accounting procedures which were previously done by manual methods. In this respect, the state-of-the-art of educational data processing is following the pattern of growth identified earlier for business applications. Payrolls, budgets, pupil registration, attendance, school marks, achievement test data, and related matters are all logical extensions of

computer experience in industry. Machines are programmed for schools in order to perform existing information processing functions, since it is relatively easy to justify the cost savings resulting from the elimination or reduction of repetitive operations now being performed by clerical personnel.

TECHNICAL TERMS, FACILITIES, AND EQUIPMENT

We have attempted to avoid unduly technical or obscure terms. However, before examining specific illustrations of practice, we must clarify both our use of some common terms and certain limitations and capabilities of electronic data processing equipment.

Most educational data processing installations employ single electro-mechanical accounting machines (EAM) which use punch cards, thus moving from paper-and-pencil processing to what are known as unit record installations. Unit record specifies that each card be acted upon before another is considered (in contrast to electronic computers which can handle cards singly but can also permit many cards to be considered before action is taken on any or all of the data they represent). After information has been transcribed onto punched cards, data processing assistance is then obtained from electrically operated machines which were originally designed to perform accounting functions in business and industry. These machines are now being used to perform similar clerical tasks in schools and are extremely useful in processing large volumes of data.

However, simple electro-mechanical machines have definite limitations. It is the high-speed electronic computer, center of advanced information system technology, which is receiving the most attention from educators. Large-scale, programmed computers, with their vast resources of speed, storage capacity, accuracy, and versatility, are now demonstrating their utility in almost every information processing aspect of education.

The computer is finding application in general business accounting - the financial and property accounting of all school business; student accounting - the processing and record-keeping necessary to guide, regulate, and record student activities; general administration - the over-all regulation, direction, and control of students and employees based upon the policies and practices specified by local, district, state, and national educational systems; and school instruction - the presentation to students of programmed curriculum materials, and the rapid retrieval of documents and reports for instructional purposes.

Any administrative rule which can be specified is one which can be programmed into an EDP system. It is the prerogative of the educator to make those inexplicable, but intuitively correct, decisions which he alone can make. Computers cannot make decisions for the educator which he has not already instructed the computer to make.

A term used frequently in this report is "system." Simply stated, a data processing system is merely terminology for paperwork procedures: the payroll system, the attendance accounting system, the grade reporting system, and so on. Electronics provides the facility for bringing all of these individual systems together into a unified,

coordinated system. In EDP, then, the word "system" usually pertains to this integrated whole.

"Hardware" refers to the machines serving to process information. Until the end of World War II, these were principally devices for handling punched cards, sometimes called Holerith cards. Electronic accounting machines (EAM) include devices for recording data in the form of punched holes, for sorting, collating, comparing, copying, and printing from these cards, and for tabulating them. The computer differs from EAM units in that it operates at much higher speeds, permits greater flexibility of control and processing, provides its own data storage (in addition to what is "stored" in the input medium itself), and provides for altering its own control and processing procedures (called programs) according to varying circumstances. EAM devices, as their name suggests, were primarily designed for accounting work; whereas computers were designed for scientific and mathematical use, although they have also proved useful in accounting and statistical work.

With the exception of scoring machines for mass processing of test answer sheets, few if any of these hardware systems have been designed with the particular needs of educators in mind. Instead, educators have adapted them to their own needs.

Machines do only what their operators and programmers tell them. Operators instruct machines by pressing buttons, throwing switches, connecting various elements to one another, or by preparing detailed programs which are executed according to precisely predetermined sequences and rules. The development of controls, procedures, input and output forms, methods of detecting error, and such "software" in general is often considered to be as costly as the hardware. A major characteristic of software is its potential for economical use by others. Capital equipment cannot easily be reproduced or shared. However, computer programs and procedure descriptions are easily reproduced. Hence, the development cost of software can be shared, with consequent savings to all concerned, given expedient modes of communication and exchange.

ILLUSTRATIVE APPLICATIONS

Succeeding pages provide brief descriptions of illustrative applications arranged in the following substantive categories: (1) educational information systems, (2) research, and (3) computer education. The intent here is to provide a sampling of resources available and of their utilization at the time of this report.

1. Educational Information Systems

a. New England Educational Data Systems (NEEDS)¹

The NEEDS program began on a modest basis in 1960 as the Data Processing Project of the New England School Development Council, in cooperation with the Newton (Mass.) Public Schools, and supported by the School and University Program for Research and Development, Harvard University. The recent recipient of a large grant from the Ford Foundation, NEEDS hopes to expand its program to include a variety of computerized services for up to 100 school systems by 1966, as well as for six state departments of education and various cooperating universities in the New England region.

In addition to performing routine activities pertaining to schedules, report cards, attendance, and testing, the NEEDS program is designed to train school personnel in educational applications of data processing technology. A level of sophistication already has been achieved which assigns 1,500 high school students to 200 courses in approximately two minutes. NEEDS scheduled approximately 20 secondary schools, ranging in size from 350 to 2,500 students, for the opening of classes in September, 1964. In addition, member schools recently received 60,000 student report cards processed by the organization.

NEEDS is a model of regional cooperation in educational data processing, involving local school districts, state departments of education, and colleges and universities. The primary aim of the program is to improve operational procedures in education with a view, ultimately, to individualizing instruction. To realize this goal, NEEDS has identified the following program interests: (1) To eliminate the information resulting from traditional procedures of record keeping; (2) To provide rapid, reliable, and accurate information for the use of state and federal agencies in their planning and financing of education; (3) To establish effective machinery for relating research to the day-to-day life of the school systems; (4) To bring technological improvements within the economic range of the public schools; (5) To develop personnel with technological skills in both education and data processing; (6) To close the gap between the sophisticated level of data processing in business and the low level of data processing in schools.

b. Total Information Service (TIS)²

The Bureau of Data Processing of the Chicago Board of Education is presently operating what is believed to be the largest and most sophisticated EDP system in school districts, utilizing three IBM 1401 computers, one IBM 7074 computer, and a professional staff of 83, which includes 35 system analysts and computer programmers. The Chicago schools computer Data Processing Center is employed in around-the-clock operations, with teaching and research applications scheduled during the day and administrative applications at night. This installation is widely considered to be a landmark, not only because of its anticipated efficient collection and economical conversion procedures, but also because of its attempt to develop a "total system approach" to data processing in schools.

An optical reader unit, the first of its kind to be used in school applications, recently has been delivered to the Chicago center. This equipment will provide a means of reading class lists and other pupil records into the system. Unlike the optical scanners which recognize the presence or absence of marks in predetermined positions, this reader converts typewritten and other printed materials into coded input to the computer. Volume of input is expected to reach 25 million documents within five years.

An example of optical scanning use is in school attendance. In this application, over 20,000 class rosters containing the names of over 600,000 children will be prepared every five weeks. These rosters, in multiple form, will be sent to the classrooms. A teacher's only responsibility will be to mark the absence or tardiness on the document. Students leaving the class will simply be crossed out with a pencil. Names of new students will be typed on the list by school clerks. When the rosters are

returned to the computer center, they will be read by the scanner. It is expected that, eventually, this record will be produced every week.

All development is being planned as a part of a total information system. The key is the development of an organization record for every facility, whether it be a school, a central office department, or a warehouse unit. The organization record is built up from factors such as the purpose of the room, the qualifications which a teacher must have to teach the subject, the availability of additional support with respect to counselors, libraries, adjustment teachers, and so forth. In the organization record, the system goes so far as to identify the playground facilities that go with the school, the boilers and air conditioning units which serve it, and the visual aid equipment available. As day-to-day transactions in finance, personnel, materials, truck schedules, or student information are performed, data flow across the organization record so that it may be kept up to date.

The total system applications of the Chicago Bureau of Data Processing are grouped within six major categories: (1) budget and finance, (2) personnel and payroll, (3) materials, (4) student accounting and student scheduling, (5) computer education or instruction in the computer sciences, and (6) research.

c. Unlimited Personnel Data Through Automation Technology in Education (UPDATE)³

In 1963, the Iowa Center for Research in School Administration began a project in educational data processing in cooperation with the College of Education of the State University of Iowa, the Measurement Research Center, the Iowa State Department of Public Instruction, and six pilot school districts. The objective is to provide local districts with increased capacity to deal with existing intricate and massive data problems and to facilitate educational research through applications of data processing and computer science. A more general intent is to introduce computer systems into Iowa schools.

Assisted by a recent grant from the Ford Foundation to the State University of Iowa, this educational data system will gather comprehensive, continuous information on school operations and pupil performance for the entire State of Iowa. This computer-based system will speed and expand the collection, processing, and analysis of data important to school administration and planning. It also will advance the study of environmental influences on student achievement.

The Center plans to collect information about all phases of educational programs in the state: students, teachers, supervisors, counselors, school boards, parents, school organization, curriculums, administrative practices, programs of special services, and facilities. In order to gain better insight into student achievement, the center will gather and relate data on teacher preparation, pupil-teacher ratios, biographical facts about students and teachers, and various other census data.

Services to be developed using electronic data processing include: class registration, class scheduling, automatic class loading, locker assignment, auditorium seat assignment, homeroom sectioning, ability sectioning, attendance accounting, preparing honor lists, reporting pupil progress, preparing guidance reports, teacher

assignment, maintaining activity fund records, providing inventories of library materials and audio-visual equipment, and preparing budgets, payroll, requisitions, purchase orders, fiscal reports, and bus routes. In addition, services which most Iowa school administrators do not now have include enrollment projections, building utilization analyses, financial projections, and unit cost analyses--all of which will be provided through UPDATE.

The Iowa Center program is highly significant in that it is designed to provide the entire range of educational data, from administrative and planning facts on the one hand, to student achievement and environmental factors on the other. If successful, the Iowa project should offer solutions to the problems of determining what data to gather, how to collect the necessary information, and how to use this information effectively. It should provide more data to support educational decision-making and, in so doing, should increase both the speed and the accuracy of the process. Development of the data system will be carried out by the Iowa Educational Information Center in cooperation with the Iowa State Department of Public Instruction.

d. Cooperative Plan for Guidance and Admission (CPGA)⁴

The Cooperative Plan for Guidance and Admission, a project of the Educational Testing Service (ETS), in Princeton, New Jersey, is an approach to the solution of a pressing educational problem - that of organizing, summarizing, and communicating all the important information that high schools collect about students. The CPGA was developed initially in Georgia, with support from the Ford Foundation and Educational Testing Service. The Cooperative Plan for Guidance and Admission involves cooperative action by educators and employers of a state or region toward the following ends: (1) Development of a "common language" and a "universal code" to be used by all schools and colleges in the recording and transmitting of information about students; (2) Application of modern electronic techniques (high-speed computers) for summarizing and communicating information about students; (3) Evolution of a system for "feed-back" of information to the high schools so that they can know the success achieved by their graduates on jobs and in colleges or universities; (4) Reduction in the costs of student record-keeping while improving efficiency.

The CPGA plan uses a standardized set of materials to record the entire record of a student, including both curricular and extra-curricular activities. At the end of the eleventh grade, all of this information is manually transcribed to a machine readable document, or transmitted via punched cards. During the summer, these data are processed, printed, and returned to the school on a multiple-part form.

This report presents a detailed picture of each student's progress in a standard format. When a student requests a transcript during his senior year, one copy of the form is updated, and mailed. This form also provides space for a college or university to return information to the high school, thus enabling schools to evaluate their educational programs.

At its computer facility in Princeton, New Jersey, Educational Testing Service is coordinating the processing of materials and now releases computer programs and procedures to state education departments and universities desiring local use of CPGA.

e. California Pilot Project in Educational Data Processing⁵

The roots of the California Pilot Project in Educational Data Processing lie in the 1959-1960 work of the State Advisory Committee on Integrated Data Processing, a group appointed by the State Superintendent of Public Instruction. This group examined the actual and potential uses of data processing for educational purposes. The results of the Committee's report led to the development of the State Pilot Project as an essential part of an over-all master plan for integrated data processing in California schools. The Pilot Project, completed in 1963, represents the first part, or trial phase, of the broad program. The second phase is now underway in Sacramento at the Research and Development Center in Educational Data Processing, State Department of Education. The third and final phase will be the actual establishment of regional data processing centers to serve California school districts.

The California Pilot Project is significant because it demonstrates that a regional cooperative venture in educational data processing is feasible. After three years of experimentation, the state project concluded that large districts, those with 20,000 or more average daily attendance, and organized regional groupings, embracing several districts within each region, could operate data processing systems with foreseeably good results. It also concluded that the regional type of system offers economic and quality advantages over local systems, regardless of size.

The Research and Development Center in Educational Data Processing will pursue its goals until June 30, 1965. The general purpose is to provide, through research and through the development of model systems and techniques, a basis of knowledge and methodology which can be used to advantage in the eventual establishment of regional data processing centers in the State and in the upgrading of district systems already in operation. The specific purposes are as follows: (1) Design and development of model systems for collecting and handling data to meet the requirements of pupil personnel and curricular functions, including the analysis of existing systems and a planned transition to more effective systems; (2) Conduct research and development in facilitating computer applications by means of programming aids such as compilers and report generators; (3) Conduct simulation studies in such areas as data processing (pre-trial of new systems) and in specific applications, such as scheduling, guidance, validation of counseling procedures, and curriculum changes; (4) Establish and maintain a library and clearing house for information relevant to educational data processing methods, systems, and equipment; (5) Develop proposals for cooperative establishment of compatible systems for the mutual benefit of local school systems; (6) Evaluate and analyze available data processing equipment and develop specifications for new equipment and its educational use.

2. Research

a. Computer-Assisted Scheduling⁶

One onerous task faced by thousands of schools is the assignment of pupils to sections according to a master schedule. Practical procedures now exist which mechanize all or substantial parts of these procedures, permitting the accomplishment in minutes or hours of tasks which formerly required weeks or months of professional time.

Initial experiments were applied to college scheduling. One of the earliest was Blakesley's at Purdue University, beginning in 1956, with the aim of devising a computer system for registering, scheduling, and assessing fees for all students as a management device directed toward the improvement in a student's choice of courses and the over-all utilization of resources. Other colleges and universities, including the University of Massachusetts, the University of Rhode Island, and the Massachusetts Institute of Technology, developed similar computer programs. International Business Machines worked out a 7090 computer program based on an early Purdue model. Subsequently, Notre Dame, the University of Illinois, and other institutions of higher education experimented with programs written for the IBM 709 or 7090 computers that could section students for the larger universities. Holz developed such a program for M.I.T. Blakesley, since then, has refined his Purdue program to schedule over 18,000 students in less than six hours of computer time, and produce an assortment of class lists, enrollment reports, and other by-products. Next step in the Purdue project, now in the experimental stage, will be the computerized construction of an "optimum" schedule of classes.

The IBM "CLASS" (Class Load and Student Scheduling) and Richmond Union High School (California) computer program named "SOCRATES" (Scheduling of Classes Realized Automatically Through Effortless Systemization) are additional research efforts in the direction of more effective scheduling in secondary schools. Anderson has developed a program somewhat similar to IBM's "CLASS" which has been coded for the IBM 7090 computer and is used by a number of school systems in the New England School Development Council (NESDEC).

Other research in scheduling presently is being devoted to the complex task of automating the master schedule in secondary school educational programs. Much of this work, such as the studies directed by Holzman at the University of Pittsburgh, is concentrated on building a theoretical model. Research is based on the use of computers in the anticipated flexible schools of the future in which each student is expected to proceed at his own pace, without grade limitations, and with an individual and constantly changing schedule. Comprehensive investigations of methods of developing these complex scheduling programs are currently underway at various centers, including the System Development Corporation, Santa Monica, California; the California State Department of Education's new Center for Research and Development in Educational Data Processing, Sacramento, California; and the "GASP" (Generalized Academic Simulation Programs) at M.I.T. The "GASP" programs, theoretical in character, offer considerable promise for assigning time, classrooms, instructors, and students to the classes required by a school's curriculum and a student's individual needs.

One practical outcome of theoretical investigations of this kind is a scheduling program devised by Oakford and others at Stanford University's School of Education, under a grant from the Fund for the Advancement of Education of the Ford Foundation. Bush and Allen introduced the Stanford programs into five west coast school systems during the school year 1963-1964. Three schools in California, one in Oregon, and one in Nevada have been scheduled in whole or in part by the Stanford programs, with more than 25 schools in the region planning this scheduling for 1964-1965. One high school in San Jose, California, used the system only for student assignment. In Stockton, California, however, Lincoln High School developed a master schedule for a

new, experimental, flexible program. Homestead High School, in Sunnyvale, California, used the Stanford programs to construct the schedule for an educational design which is gradually incorporating many innovations, including team teaching.

The Stanford scheduling system's biggest undertaking to date has been the scheduling of Marshall High School, Portland, Oregon, which enrolls approximately 2,000 students in a highly experimental program. Marshall School is characterized by twenty-one daily time modules of twenty minutes each which can be scheduled singly or in combination; school-wide team teaching; independent study averaging one-third of each student's time; the organization of instruction into small, medium size, or large groups; and many other interesting innovations.

b. Computer-Based Laboratory for Automated School Systems (CLASS)⁷

The System Development Corporation (SDC) in Santa Monica, California, has been using a very sophisticated computer facility designated CLASS for the research and development of an instructional system designed to provide optimal learning conditions. CLASS permits simultaneous automated instruction of twenty students, each of whom receives an individualized sequence of instructional materials adapted to his particular needs or learns in a group mode of instruction mediated by the teacher or computer. Application of modern data processing technology to other functions normally associated with a school district also can be employed in CLASS.

In the CLASS system, each student has a manually operated film viewer containing 2,000 frames of instructional material. In addition, he has a response device, linked to the computer, which indicates the sequence of slides to be seen by the student, enables the student to respond to questions, and presents knowledge of results to the student in the form of a coded light. The computer maintains performance records for all students supplying these records to the teacher, counselor or administrator.

Provision is made for two teachers in CLASS. Each teacher has console facilities which make it possible for him to call up computer-generated displays showing the current progress of any student or group of students. Automatic alarm lights alert the teacher to students who are performing unsuccessfully in any lesson. CLASS also permits instruction through media such as television, films and slides, and conventional lecture and textbook methods, permitting instruction in either the individual or group mode. Studies of the impact of automation on the roles of guidance, instructional, and administrative personnel can readily be carried out.

c. PLATO⁸

Another computer research facility in the area of automated teaching is "PLATO," a project being developed in the Coordinated Science Laboratory of the University of Illinois. The main objective of PLATO is to provide a system capable of tutoring a large number of students concurrently in a variety of subject materials.

To accomplish this aim, the system uses a high-speed digital computer as the executive control element. As the students' requests arrive at the computer, they are accepted and processed sequentially. Computer speed permits all student requests to be processed without noticeable delay. Besides acting as the control element, the com-

puter records the students' requests and later processes the records for information relative to both students and lesson material. Changes usually are implemented by altering the computer program instead of rewiring student stations.

Because of the flexibility of the PLATO system, improvement in automatic instruction is viewed as a two-dimensional process. First, there is improvement in lesson material, both content and organization. Second, there is improvement in pedagogy, especially strategies of teaching. An attempt is being made to develop a system which will adapt to each student's immediate needs. Instead of concentrating only on developing improved lesson material, an effort is being made in PLATO to measure the student's performance, and to determine his difficulties and characteristic behavior. With this knowledge, alternate approaches are provided for the student when one approach has not met with sufficient success. The ultimate purpose is a cumulative record of student behavior in an effort to refine the most appropriate teaching strategy for him.

d. Computer Simulation

With the advent of the digital computer, simulation techniques have been used for purposes in addition to instruction. Computer simulation for effecting the analysis of an operational man-machine system and aiding the development of an advanced system design, has proved to be productive. The complexity and detail with which the system can be simulated and the variety of techniques used to study, manipulate, and alter the system in order to achieve some new objectives or to monitor ongoing functions were not possible before computers came into use. For analytical purposes, simulation has all the traditional advantages of the laboratory over contextual or field research. Whenever a real system is too large for observation, laboratory simulation can be used.

At Purdue University and the St. Louis Junior College District, for example, simulation techniques are being used to forecast building and staff requirements under varying academic conditions. At System Development Corporation, under a U. S. Office of Education grant, computer simulation is being utilized to study various types of secondary school organization as they affect the implementation of innovations in school practice: particularly space utilization, school organization, information handling, and teacher role and responsibilities. Experimenters have been able to simulate 1,000 students going through a "continuous progress" school, with a view to comparing the number of steps required by both "slow" and "fast" students in completing a given unit of work. Important insight into individualized instruction is thus being obtained. The over-all goal of the project is to use the simulation model to study changes in school structure and operation, with documentation of time utilized in each activity. Programming is being done in JOVIAL J-3 for the Philco 2000 computer.

3. Computer Education

Knowledge of electronic data processing techniques is recognized as a valuable complement to high school and junior college education geared to today and tomorrow. No student ought to leave our schools without some understanding of automation and information processing, considering the important changes these are bringing to the adult world. High school graduates with knowledge of how to use electronic machines in business practices and with skills in operating them have an excellent market for their services today. Specific courses of study are being developed for vocational

education, and vocational education teachers are advancing their own ability to teach the needed courses. Most of the existing formal preparation in EDP has come from colleges and universities, but there is growing recognition that computer training must be brought to the high school level. Roughly one out of three high school students does not graduate; a second does not continue his education beyond a high school diploma; and so only the third, the college-bound student, will benefit from EDP courses offered in higher education.

Details concerning the current status of student instruction in the computer sciences are provided in Appendix B and are not repeated here. There is a growing recognition among schools and colleges that computer education is needed, not only in vocational and other technical training programs, but in general education as well. In the Chicago public schools, for example, the computer instructional program includes a two-year course of study at the junior college level for the training of programmers, and four semesters of preparation for prospective teachers of data processing. In addition, a pilot program for high school seniors is being planned in two schools this year. It is anticipated that this offering will be expanded to all 55 high schools within a two-year period.

SUMMARY AND ANALYSIS

Automated methods have found limited but rapidly growing application and acceptance when there are masses of fairly precise data related to well-defined tasks; when processing is highly repetitive; when the rules for decisions can be specified with great precision; when it is necessary or desirable to repeat processes many times under varying conditions; when data are to be analyzed by "brute force" heuristic methods rather than according to a logical plan; and when there is great demand for high speed or multiple precision. When the computer has been applied appropriately to educational data, it has reduced the amount of professional time and energy previously devoted to clerical work; it has reduced the unit cost of processing educational data; and it has facilitated the development of new techniques, resources, insights, and processes not feasible under manual or tabulating machine systems.

Perhaps one of the most valuable results of the introduction of EDP technology in education has been the accompanying need to examine with precision the nature of educational rules, procedures, customs, arrangements, schedules, objectives, and assumptions. If automated processes must provide for a variety of foreseeable events and contingencies, these must be anticipated and defined without ambiguity. Since machines will in general do only what their operators cause them to do (assuming no random malfunctioning), those who design EDP systems must understand both the characteristics of the machines - and hence the state-of-the-art as a whole - and the requirements which the machines are to satisfy.

One aspect of the present state-of-the-art is certainly the state of mind of the educator as he considers the present and possible uses and effects of EDP. When educators place increased reliance on mechanical processes, they must understand what these processes imply. Mere access to more data does not ensure their wise selection or use. It is fair to say that the general technology has advanced well beyond our application of it. The most striking feature of the state-of-the-art is the disparity

between practice and potential, both in the nature and scope of applications and in the breadth of understanding and acceptance of the power of these applications to improve education.

Preliminary analysis of computer applications in education readily reveals certain problems or obstacles. The following appear frequently enough in local, state, or regional programs to present roadblocks to the further development of computer systems in education:

1. A significant number of automated EDP system developments are designed to perform more easily and quickly the same things educators have been doing all along. The need now is to utilize techniques and equipment for what has not previously been possible.

2. There is no accepted standardization for data processing at the national, state, regional, or local levels. Teacher and student mobility within and between states has highlighted the need for system compatibility.

3. A concerted effort has been directed toward the development of new systems, new products, and new applications. Considerably less effort has gone into maximum utilization and efficiency of present developments. Consequently, the relatively few developers have advanced far ahead of the users.

4. Educators, by and large, are inadequately prepared to take full advantage of computers and electronic data processing applications. Even if they perceive the computer's potential, there is, at present, little opportunity for educators to obtain the training they need to bring computer capabilities to bear on educational problems. By the same token, the computer system specialist is also limited in his perception of the educational problem areas within which the power of the computer can be appropriately applied.

5. Many computer applications have been developed on a single system basis, i.e., attendance accounting, grade reporting, test scoring, etc. Little effort thus far has been devoted to the development of an integrated data processing system. Educational information system developments appear often to be designed as ends in themselves rather than as means to an end. Research and development directed toward the understanding of relationships between one kind of student information and other kinds are embryonic, at best.

6. There is presently no clearing-house of and for information. As a consequence, there appears to be much duplication of effort; repetition of errors; and wasteful use of time, scarce talent, and financial resources.

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CHAPTER THREE

THE LAKE ARROWHEAD CONFERENCE: PROBLEMS, ISSUES, RECOMMENDATIONS, AND CRITERIA

Preceding descriptions and analyses imply pressing problems and issues pertaining to the application of electronic data processing methods in education. To this point, not all of these have been made explicit. The effort to make them explicit was expedited substantially through a Colloquy held as part of this project at the University of California's Lake Arrowhead Conference Center. The writers take full responsibility for their identification, interpretation, and wording of issues, problems, and tentative recommendations appearing to rise out of the Colloquy and summarized here. The chapter concludes with a listing, somewhat re-worded from the original statements, of criteria suggested to funding agencies for possible use in the demanding task of selecting and supporting worthy requests for financial support.

As stated in the Foreword, the thirty-seven conferees assembled at Lake Arrowhead included specialists in educational data processing, teachers, curriculum and guidance specialists, administrators, psychologists, information scientists, and research workers. They represented state departments of education, public and private schools, colleges and universities, and various organizations and associations. Participants are listed in Appendix A.

Conferees were asked to prepare, in advance of their coming, brief papers summarizing what they considered to be problems and gaps in automated school information systems as well as needed research and development. The writing of these papers stimulated some preliminary thinking; papers distributed at the Colloquy stimulated discussions; and later perusal of them by the investigators stimulated formulations of problems and issues. In essence, they opened windows to the thoughts and activities of persons actively engaged in or concerned about EDP in education.

The charge to the discussants at Lake Arrowhead was three-fold: (1) identify problems and issues pertaining to automated school information systems; (2) suggest needed research and development; (3) set forth criteria to assist funding agencies in judging the merits of research and development proposals submitted to them. At opening sessions, specialists on the use of EDP in education reported on the state of the field and an educationist identified some of the pressing educational problems to which automation of information processing might bring relief. These problems ranged from the management of data pertaining to general administration, personnel, budgets, and facilities to complex instructional and research activities. (See Table 1 in Chapter One). In addition to general sessions, there were four small discussion groups meeting singly and in combination with each other group: learners and electronic data processing, teachers and electronic data processing, institutions and electronic data processing, and system networks and electronic data processing.

As sometimes happens in a cross-disciplinary encounter, especially in a search for consensus, irritation with the opinions of others ran high at times and most of the participants left the conference with the feeling that they had failed to make other

participants understand some major point - in fact, that the conference had not achieved its purposes. From the beginning and throughout, the problem of communication loomed large as one to be taken seriously in all efforts to automate informational processes in education.

The essence of the total conference might be characterized by the word, "dis-agreement." And yet, certain agreements were virtually assumed: the need for uniform definitions and terminology; the need for educators and technologists to work together more closely in automating school information systems; and the prevalence of fear of the machine among educators. Some of the most significant disagreements focused on the following: the matter of what the computer can and cannot do; what use is to be made of time saved through automating educational processes; whether or not educational technology is ahead of the educator; the preparation of material for computer processing; the uses of processed data; the special training of EDP personnel in education; and educational lag in employing the new technology. Only the most superficial of discussions could produce quick agreement on topics so fraught with issues!

In spite of frustrations and difficulties, Colloquy participants came to grips with some critical problems, posed recommendations for their solution, and suggested some criteria for funding research and development projects.

PROBLEMS AND ISSUES

Subsequent analyses of tape recordings from the conference suggested five problem areas: (1) electronic data processing in the educational setting; (2) electronic data systems; (3) electronic data processing and the school program; (4) education in the use of electronic data processing; and (5) electronic data processing information exchange. Naturally, there is considerable overlap of specific problems within these general areas; nonetheless, this clustering appears useful.

1. Electronic Data Processing in the Educational Setting

At various times, discussion centered on the place of electronic data processing in the broad setting of American education. Discussants wanted more information about the experiences of those educational agencies already using EDP: What purposes have they set out to fulfill? What difficulties had they encountered and what solutions had they formulated for overcoming them? There were queries concerning the effects of EDP on school personnel, on organizational structure and administrative procedures, and on the conduct of instructional programs. Discussion focused, also, on why some schools and school systems were reluctant to employ automated information processing systems.

These kinds of problems proved difficult to deal with in the Colloquy setting, partly because of the differing interests and backgrounds of participants. Nobody felt qualified to generalize from his own information and experience. Clearly, the kind of information sought here is needed on some continuing basis.

2. Electronic Data Systems

As might be expected, much discussion focused on equipment (hardware), programs (software), and the compatibility of EDP systems. Regarding the problem of what EDP can and cannot do, concern was expressed that some people have come to expect too much of the computer. The analogy of the human brain in explaining computer capabilities has been overdrawn. The computer can do only what some human has programmed it to do - with superlative efficiency, admittedly. The need for an effective, continuing program of information regarding the technology of automated information systems in education is apparent.

Considerable confusion prevailed at the Colloquy concerning the appropriateness for education of equipment designed primarily for business, industrial, and military needs. It was suggested, for example, that the kind of computer needed to monitor a missile is not what is needed to prepare a student's class schedule. Actually, the needs of education do not exceed the general purpose nature of computer equipment. Computer software, however, must be designed specifically for education. Costs of hardware and software may very well necessitate some unique cooperative strategies among schools and school systems in getting full return from their investments. But the availability of computers engineered specifically for education is not the problem. The educator's unique problems are in programming but, even here, many general techniques are applicable.

The interface problems - that is, of translating educational processes into terms that can be manipulated by the computer - is a formidable one, according to conference participants. Educators do not know how to get data ready for the computer and are unable to use them when they come from the computer. Electronic data technologists ask for data in terms that are unfamiliar to and awkward for the educator to handle, and the data are returned from the computer in equally puzzling forms. A human interface problem was very evident at the Colloquy, as mentioned earlier. The educators present were unable to express their problems in language that could be fully interpreted by the EDP specialists. Likewise, the problems seeming to most fascinate the latter appeared to many educators to be of *secondary significance*. The extent to which these two groups talked past each other is a revelation justifying the conference. Without experiencing this confrontation, it would have been difficult to predict the formidable communications gap. Other groups have worked through the problem simply by developing a few systems together.

Problems pertaining to the compatibility of data processing systems emerged again and again. What are the potentialities of state, regional, and even national programs? Can the needs of local school systems be met adequately by a remote storage and retrieval unit? What kinds of data can be gathered appropriately to serve the interests of many cooperating school systems? At present, school systems are not alike in their designations of responsibility for decision-making, nor in the identification of data deemed essential. Consequently, one technologist's "total system" becomes another's sub-system. Different groups of people require differing sets of data; there is little agreement on terminology by means of which individual needs can be described. This quagmire of problems and questions occurs in every major field of application of EDP. The practical limitations that cut a system down to size are the dollars, time, and intellectual resources available to the design team and the political interactions among the potential users.

3. Electronic Data Processing and the School Program

Problems of school business accounting and of personnel accounting came in for relatively little discussion, perhaps because the potentialities of EDP techniques are relatively clear here and considerable progress already has been made. But the possibilities of automated data processing procedures in student counseling and instruction aroused animated and, in the case of the latter, sometimes heated discussion. Characteristic of both counseling and instruction is the need to conceptualize, collect, up-date, and retrieve cumulative data on the individual learner. These data must be available at critical decision-making points. Information includes academic achievement, interests, psychological and physical well-being, previous courses, significant facts of home and school history, special aptitudes, and so on.

The problems involved are reasonably manageable when decisions such as inter-class grouping are to be based on ability or achievement data. But they become complex, indeed, when schools committed to highly individualized instructional procedures attempt, for example, to place students in appropriate groups on the basis of an array of personal data on both learners and teachers. The problems lie not with the capabilities of the computer but with the human sophistication required in conceptualizing the data needed, collecting them efficiently, and then translating them into terms appropriate for computer processing.

During some of the Colloquy discussions, it became clear that some educators fear the early standardization of pupil personnel data for EDP systems, at a time when insights into the requirements for effective learning and teaching are changing. They fear that heavy investments now in inadequate or inappropriate automated data systems will inhibit change later. Some of the EDP technologists present, on the other hand, were somewhat impatient with these educators' reluctance to begin with data already available. Again, the communication difficulty appears to rise in part out of the educators' limited insight into the capabilities of computer-based information systems and the technologists' understandable lack of insight into the subtleties of modern educational advance.

4. Education in the Utilization of Electronic Data Processing

All four of the small discussion groups focused at some time on questions pertaining to training personnel in EDP for the field of education. A substantial number of participants expressed the view that a kind of middleman must be developed; that is, a person who is essentially an educator but who also understands computer operation and is able to program for it. Support for this view may have been due to the large proportion of such persons in attendance. The extreme of this position, expressed in the conference, is that departments or schools of education should offer a sequence of courses for the preparation of educational EDP personnel.

A sharply divergent minority point of view also emerged. In brief, it is that information scientists should - and will - enter the field and, in association with educators, will develop the necessary data processing systems. No middleman is necessary. Through interaction and joint attack upon problems, the educator learns computer capabilities and the information scientist grasps such understanding of education as is essential.

Colloquy participants also gave some little attention to the place of computer science knowledge in college and pre-college curricula. It was generally agreed that the mathematics programs of secondary and higher education should, and increasingly do, include principles of computer functioning. It was noted, too, that even some elementary-school pupils are being introduced to the binary number system and computer concepts. Their parents, though, rarely have had such advantages!

5. Electronic Data Processing Information Exchange

This aspect of the discussions dealt with communication within the field of electronic data processing, with particular reference to educational applications. As in every new and fast developing field, those involved are vaguely uneasy over keeping abreast of the times. Often, they feel that the world is passing them by, that momentous things are happening "out there."

From a very practical standpoint, a flow of information is necessary simply to avoid duplication and thus to make wise use of scarce resources in time, talent, and money. There is need for a clearing house - or, as someone expressed it, a "switching station" - to keep pertinent information moving from and to the scores of individuals, institutions, organizations, and associations intimately or peripherally involved with the problems.

RECOMMENDATIONS

Colloquy participants, as a total group, posed no recommendations in the formal sense. They did not vote or otherwise indicate majority points of view or consensus. But small discussion groups, on returning to general sessions, posed informal recommendations as a means of identifying avenues of agreement and disagreement. To avoid repetition, these are not stated here. Instead, they have been put together with those of the investigators to constitute a section of the next and final chapter. However, in order to do justice to the Colloquy the kinds of recommendations suggested by these small groups are briefly sampled below.

1. In regard to problems of compatibility among information processing systems, it was recommended that there be inquiries designed to standardize nomenclature and definitions. These should accompany or precede studies of "total systems" requirements of automated school information systems, involving the identification of procedures and practices by which compatibility among "sub-systems" might be maintained.

2. Training problems received much attention. One recommendation proposed that a relatively large body of school personnel be educated in the capabilities and limitations of EDP and that efforts be made to acquaint educators and EDP technicians with their respective techniques and concerns. However, there was disagreement concerning the depth and scope of EDP knowledge required for educators in general. One group of Colloquy participants went on record as saying that we do not know what knowledge is needed by various groups of professional educators and recommended that funding agencies support projects designed to identify this body of knowledge and to develop curricula appropriate for educators seeking to become involved in educational FDP.

3. In the realm of student counseling and instruction, there were recommendations for research and development designed to determine the data most needed by counselors and teachers, the possible applications of EDP to curriculum development and revision, and the potential uses of EDP in analyzing the learning problems of individual students.

4. Discussion of the special software needs of EDP in education produced no specific recommendations but underscored the need for improving input and output procedures for automated school information systems.

5. There were several suggestions for expediting communication in the field of EDP applications to schools. Especially needed is some cumulative record of progress, with accompanying analysis of common difficulties and the success or failure of various strategies in seeking to overcome these difficulties.

No effort was made to establish priorities for research and development. Rather, it was hoped that efforts in the realms of research, demonstration, development, and service might move forward simultaneously, each profiting from advances in the others.

CRITERIA FOR FUNDING PROJECTS

The third charge to Colloquy participants was to formulate criteria which might prove useful to funding agencies faced with the difficult task of choosing among proposals competing for financial support. In a sense, the recommendations growing out of the Lake Arrowhead Colloquy and out of the investigators' inquiries (see Chapter Four) constitute substantive criteria; that is, they identify problems worth investigating. The questions formulated below, products of the final conference session, provide what are essentially non-substantive or process criteria. They might be applied to any proposals for support to study or develop automated school information systems, whether or not dealing with the topics identified in this report.

1. Will the results of the project be generalizable; that is, will they benefit agencies or groups other than the one being developed or investigated? For example, cost is a significant and often deterring factor for school districts. It would be immeasurably helpful were more data available pertaining to costs of various kinds of systems in varying sizes and combinations of school districts.

2. Will the project advance educational goals by removing a roadblock or otherwise resolving a recognized problem? For example, computerized methods of scheduling facilitate the development of highly individualized student programs in secondary schools. Similarly, the computer may very well play a key role in guiding pupil placements in elementary schools, employing many items of personal data in arriving at each decision.

3. Are there provisions in the proposal to facilitate dissemination and replication? Often, the preparation of a project report satisfies the information needs of only a small audience. Replication is impossible unless full details regarding purposes, procedures, and findings are provided.

4. Is the proposed project both cumulative, in that it builds on what is already known, and additive, in that it proposes to create new tools, techniques, or knowledge? The project proposal, then, should reveal the investigator's knowledge of the field and rather precisely how he intends to add to what is known.

5. Will the project provide for more efficient use of existing knowledge, techniques, and tools? For example, the tedious counseling process of predicting student success on the basis of past performances is vastly expedited through the use of EDP equipment.

6. Does the project offer promise of improving research conditions or school practices in some significant educational realm? For example, highly sensitive pupil placement and instructional procedures based on many factors of child development, and subsequent research into the consequences of these educational decisions, simply could not be contemplated without access to the computer.

7. Does the project offer promise of maximizing scarce resources of time, money, and personnel? For example, assistant superintendents for teacher personnel and for instruction often become so bogged down with detail that their proper jobs - for which nobody else is as well prepared - go begging. Many of their routine information processing chores might well be automated.

8. If the project is to have significance for a wide range of school systems and personnel, have the capabilities of intended users been accounted for? Use of the results may require a sophistication not generally available in the intended application settings, or the need for mounting subsequent in-service training programs.

9. If the project can be consequential only if activities are to continue following termination of the grant, are other funds available for such self-sustainment? Or, will there be a need for continual infusion of outside funds?

10. Does the project offer promise of planting the seeds of sustained self-growth? The hope is that educational institutions and organizations increasingly will become self-sufficient in EDP through the experience and resources acquired initially in research and development projects funded by outside agencies.

Obviously, not all of these criteria are pertinent to every request for funds. Many are nothing more than criteria for judging any piece of research. But anyone experienced in reviewing grant requests knows how frequently such common sense conditions are ignored or not understood by would-be investigators.

Conferees were unable to agree on priorities for these criteria. However, they did agree on the following four suggestions to funding agencies:

1. Funding agencies faced with the task of reviewing and selecting proposals for supporting grants should seek the advice of persons competent in both electronic data processing and education.

2. Projects of an applied nature, intended for use in real-life settings, should be tested in real-life settings.

3. High priority should be given projects designed to implement in the context of education what is already known about electronic data processing. The primary barriers seem to be the relative unavailability of knowledgeable personnel sufficiently high in the administrative structure to affect decision-making; inadequacy of resources necessary to getting started, especially in moving from simple punched card methods to the use of a computer; and general ignorance and indifference within the education profession regarding the capabilities and potentialities of automated information processing.

4. High priority should be given, also, to problems of intersystem compatibility, of establishing and maintaining good communication among educational systems and agencies through the development of common terminology, nomenclature, definitions, and standards.

CHAPTER FOUR

SUMMARY ANALYSIS: RECOMMENDATIONS AND CONCLUSIONS

The investigators' experience with the Lake Arrowhead Conference, together with their review of current applications of computers and information processing systems in education, suggested several areas of needed research and development. Recommendations pertaining to these areas are set forth below, organized around the categories used for presenting problems and issues in Chapter Three. These recommendations and the process criteria with which Chapter Three concludes are addressed to funding agencies seeking to determine the relevance and significance of grant requests submitted to them.

RECOMMENDATIONS

A. Electronic Data Processing in the Educational Setting

The literature of experience with EDP in education is scant. The successes, failures, trials, and tribulations of the business and scientific communications, however, has been well documented. Education will have to develop its own specific body of knowledge pertaining to the problems and processes involved. Much useful experience already has been acquired by workers in the new vineyards. It simply needs to be collected, processed, bottled, and labeled for easy identification and use.

1. RECOMMENDATION: That studies be encouraged which seek to identify problems and procedures in the development, utilization, supervision, and administration of automated school information systems. Specifically, some studies should focus on changes resulting from the implementation of EDP: in administrative and organizational structure, in personnel utilization, and in curriculum and instruction.

B. Electronic Data Systems

The substantial belief among educators that vast differences between educational problems and problems in business, industry, and the military necessitate the use of essentially different hardware and software warrants careful investigation. The differences in software requirements of installations set up for varying purposes are readily recognized. But this persistent belief concerning hardware requirements suggests considerable misunderstanding of computer capabilities.

2. RECOMMENDATION: That studies be conducted to determine the special hardware and software requirements of electronic data processing in education.

The problem of where to place the automated data processing system in the structure of school district organization in order to get maximal usage is still relatively unexplored.

3. RECOMMENDATION: That support be given to studies designed to determine how the user can get full value from the system and how systems can be designed

to assure responsiveness to a wide range of demands. Management studies similar to one conducted by the McKinsey Corporation would be appropriate. The focus was on discerning what contributed to profitable rather than less-than-profitable use of electronic data processing by major industrial users. The most successful users had the benefit of top management approval and training in EDP. Thus, the data processing design team was located at a high enough level of management to be able to take a broad look at problems. The systems that developed under these circumstances more than paid for the costs.

Some of the most complex problems in designing data systems for education arise out of difficulty in determining the minimal basic items required for information processing tasks, especially in these times of educational change. (See Chapter One). Until some guidelines are available here, school districts will be reluctant to enter into cooperative data processing ventures on state or regional bases for fear that the information to be processed will not adequately serve their needs. And yet, for economy and efficiency, collaborations among school districts, particularly small ones, appears to be highly desirable and, in some instances, necessary. Recognition should be given to recent software developments that allow some flexibility in the creation of systems under circumstances where it is difficult to specify the exact initial data requirements.

4. RECOMMENDATION: That studies be supported which propose to recommend basic minimal data items for information processing in various aspects of education (facilities, teacher personnel, budget, students, curriculum, and so on) at several different levels of educational functioning (i.e., local single districts, local combinations of districts, state, regional, and federal). Projects might well develop handbooks as an aid to standardizing terminology and definitions.

Studies of this kind provide only part of the information needed in seeking to design systems which satisfy the inter-dependency demands of school entities and agencies. The ultimate need for compatibility among data processing systems should be recognized and planned for at the outset of involvement with EDP.

5. RECOMMENDATION: That studies be supported for the investigation of procedures and practices by means of which total systems compatibility in EDP systems of varying sizes and complexity might be established and maintained.

Studies of minimal data item requirements and of information processing systems compatibility would lay the groundwork for studies designed to determine the kinds of software necessary to broad-scale operation of EDP in education. Much of what is needed is standard but the commercial production of what is not standard for users in other fields may very well be held up until assurance of marketability is forthcoming.

6. RECOMMENDATION: That studies be supported for assessment of the special and unique needs of education likely to be encountered in the future as EDP use becomes established.

The inter-related nature of the studies recommended in this section on electronic data systems places a responsibility on funding agency personnel. With very little revision or additional work, a project proposal in one of these areas might be amended to cover one or more additional areas. When separate but potentially supporting studies

are funded simultaneously, agency officials could be of service in bringing the investigators into communication with each other.

C. Electronic Data Processing and the School Program

Automated scheduling of the course loads of students in secondary schools already has been successfully demonstrated. The need now is for large numbers of high schools to take this significant step. But most of these demonstrations have involved schools using relatively traditional patterns of organization and group instruction. The use of EDP in scheduling highly individualized programs in schools seeking to modify conventional procedures is only beginning to open up.

The kinds of decisions educators make determine the kinds of data they need for making them wisely. Conversely, the kinds of data available frequently pre-determine the kinds of decisions with which educators concern themselves. In the immediate past (and still predominantly in the present) educators buttressed their estimates of student ability and progress with standardized intelligence and achievement test results, when such information was available. And these were essentially the only diagnostic data available to them. Further, these data fitted the prevailing concept of what education was for and vice versa.

As we move today toward individualized programs facilitated by new patterns of school organization and comprehensive packages of instructional materials, the pupil diagnosis and prescription called for demand new data and more sophisticated use of them. Teachers have not yet in general either perceived or been prepared for the kinds of decisions which they increasingly will be called upon to make in the future. Further, they usually do not yet see the possibilities inherent in having available to them many items of information not previously available. It is imperative, therefore, that educators stay very close to the tasks of defining, collecting, and providing the data needed. Otherwise, EDP personnel are likely to develop systems which perpetuate the provision of data pertinent to relatively routine educational tasks of the past but inappropriate to increasingly sensitive educational decisions of the future. A new kind of school is emerging, calling for new kinds of data about students and their learning and, therefore, for the closest collaboration of educator and information specialist in collecting these data.

7. RECOMMENDATION: That support be given to projects seeking to couple automated data processing techniques with the development of innovations in scheduling, counseling, school organization, curriculum development and instruction. Such projects hold promise for revealing to us what "the new school" might look like were a whole range of educational changes to be introduced simultaneously.

As became so strikingly apparent in the Lake Arrowhead Colloquy, there simply can be no overstatement of the need for educators and data processing personnel to come together in every possible circumstance designed to promote mutual understanding and uncluttered avenues of communication.

8. RECOMMENDATION: That funds be made available for the organization of conferences on EDP in education, perhaps similar to the Lake Arrowhead Colloquy in their provisions for physical propinquity and resulting frank discussion, in which representatives from the whole range of personnel making up the field of education will be involved.

If individualizing instruction is to become more than a slogan, data to guide diagnosis, information on the consequences of decisions, and data to facilitate reassessment are essential. The quantities and varieties of data to be stored and retrieved, to say nothing of the manipulations of these data to be performed, defy human capabilities. We are now beginning to envision for the teacher a highly professional role of diagnosing and prescribing for the learner. But this role may never be fulfilled unless the computer is brought meaningfully and productively into these sensitive, often intuitive acts, as supplier of essential data and as predictor of certain possible consequences of choice. As yet this fertile soil has been scarcely gazed upon.

9. **RECOMMENDATION:** That funds be allocated to pilot projects seeking to open up possibilities for individualizing and otherwise enhancing schooling opportunities for all children and youth through the conceptualization and electronic processing of those data deemed most important for the range of educational decisions and processes involved. This is a tall and expensive order. The essence of the matter is the use of EDP for opening up fresh possibilities in what is now a primitive part of the educative enterprise. It is but little concerned with automating what is already manually operative, important as is this more conventional phase in the maturation of EDP in education.

Many of the projects fitting the intent of this recommendation are likely to be related in some way to the forward thrust of American education generally. For example, when the traditional ways of placing children in grades and classes are stripped away through the creation of nongraded, team-taught schools, what kinds of data are now needed by teachers seeking to take advantage of their new organizational flexibility? Can such data be programmed efficiently for computer processing and then be retrieved so as to be employed efficiently in teachers' decision-making? Can this be done economically? Similar kinds of questions about determining appropriate curricular sequences might well be investigated. Unique possibilities for monitoring or for simulating learning or teaching strategies also are opened up. The search for learning environments responsive to individual needs also suggests much more extensive and sensitive use of the computer in storing and retrieving instructional materials.

The projects suggested here extend far beyond the automation of school accounting, scheduling students, and scoring tests - activities which too often tend to come rather exclusively to mind when the uses of computers in education are discussed. Further, they suggest hitherto little explored roles for guidance counselors, especially in elementary schools where the functions of such personnel have never been clearly defined.

At first, these kinds of investigations are likely to be expensive from the point of view of volume of data handled in relation to the EDP facilities required. The broken front character of educational change complicates the problem of inter-school or inter-district cooperation in developing experimental information processing systems because seldom are several schools simultaneously engaged in developing new innovations. Consequently, considerations other than volume of data in relation to cost must enter heavily into determining the merit of grant proposals. Funding agency personnel must be acutely attuned to the advancing front of school experimentation or draw heavily upon the advice of people who are.

D. Education in the Utilization of Electronic Data Processing

The lag in using EDP in education is formidable. Simply to implement for education what is now commonplace in enlightened divisions of other fields would produce startling changes in the educational fabric. A shortage of persons knowledgeable about both education and EDP is commonly held accountable for much of the blame. But there is far from agreement on how such persons should be selected and trained. The ultimate production of a steady stream of college graduates, some of whom will follow careers in education, whose curricula have included studies in computer science offers a belated solution - but much too belated. Provision of courses directed to the educational applications of electronic data processing in the pre-service and in-service programs of teachers offers an immediate but superficial solution. The problem is clear but the obvious solutions fail to promise relief that is both early and substantial.

10. RECOMMENDATION: That support be given to projects designed (1) to identify the formal education and direct experience that would be most helpful in enabling educators and EDP personnel to develop appropriate operational understanding of their respective domains; (2) to translate these training needs into sound instructional programs; and (3) to demonstrate these curricula and disseminate information about their effectiveness.

E. Electronic Data Processing Information Exchange

It is difficult today to collect relevant, detailed information about what is happening in the field of EDP applications in education. As a result, there is much duplication of effort, repetition of mistakes, and waste of scarce human and material resources.

11. RECOMMENDATION: That a national, central clearing house be established, not as a repository of materials and programs but as a switching center, for promoting the exchange of technical information and materials on EDP in education. Its main function would be to provide information about who is doing what and where, thus facilitating the exchange of views and activities among school districts, government agencies, and various other organizations or associations. The National Education Association or the United States Office of Education might appropriately perform such a function.

General

Several additional kinds of research and development projects might be considered here. The point is made several times in this report that the employment of EDP in education has been retarded by educators' negative attitudes toward and limited knowledge of automation. Actually, we know very little about either the prevalence of these unfortunate limitations or their specific nature. It is time that we found out precisely what exists so as to know what we are dealing with in seeking to develop remedial measures.

Educators from time to time express fear that the incorporation of human programming errors into machine functioning will effect undetected injustices and inconveniences for students and teachers. How frequent and how serious are the errors now being committed by EDP? Do they go undetected? And how do the frequencies and impact of errors using automated information processing compare with similar operations that are manually processed?

How have teacher roles been affected in schools or school districts making extensive use of automation?

Not only do we need answers to these and other questions but, in addition, there is urgent need for demonstration projects of many kinds, especially projects in secure or controlled situations that permit the admission of shortcomings or even of failures outweighing successes. The effective exploitation of trial situations suggests the need for temporary assignment of competent EDP analysts to them. Nothing quite equals demonstrations with accompanying frank admission of shortcomings as well as assets, for giving the skeptical or ill-informed a sound basis for re-examining views which otherwise might soon petrify.

IN CONCLUSION

The essence of our findings and present point of view toward the application of electronic data processing in education can now be set forth in a series of statements, each of which serves as topic sentence for eight short, succeeding paragraphs. Admittedly, they do some violence to the report as a whole since they tend to obscure many other problems, issues, and conclusions. Nonetheless, there appears to be some usefulness in putting together for the reader those ideas that most nearly express where we have arrived after our journey through the information processing intricacies of education.

No further research needs to be directed toward answering the question of whether it is practical and useful to apply automation to the solution of educational data processing problems. Education is essentially an information processing enterprise in that huge masses of information are essential to its management and, for that matter, to the processes of inquiry which make up good teaching and learning.

The field of education is still primitive in its commitment to and use of electronic data processing in those mass procedures pertaining to personnel, budget, facilities, and materials in which business, industry, and the military already have effectively demonstrated the benefits in economy and efficiency. Some of the problems are economic: not merely the problem of financing initial cost but also the difficulty of computing gains in efficiency and personnel re-deployment in relation to input factors. But most of the problems lie in the realm of understanding and communicating, especially at management levels.

The most formidable block to progress in educational applications of EDP is not the state of the data processing art, but our understanding of education as it presently operates and is likely to advance, especially our insight into the relationship between the human beings involved and the vast accumulation of organizational, instructional, and various ad hoc techniques that presently constitute our education system. Part of this difficulty relates, in turn, to the crazy-quilt pattern of school district organization in America. Witness, for example, the data processing dilemmas involved in seeking to coordinate the information system of a secondary school with those of six elementary schools supplying children from three independent school districts! The difficulties are further compounded when four of these elementary schools are traditional in procedures and two represent the latest in classroom organization, curriculum content, and instructional innovations.

There is a growing need for a "literature of experience" providing blow-by-blow accounts of how forward-looking states and school districts have resolved these difficulties of relationships and other problems in setting up automated school information processing systems. Success stories alone are not enough. Unfortunately, it has always been difficult in education to ferret out information about potentially useful failing ventures. Too many school leaders, after the arduous labors of convincing their boards and explaining their plans to the public, conclude that failure simply must not be admitted.

There is a retarding communications gap between educators in schools, colleges, and universities who are strategic to the ultimate utilization of EDP in education and those various specialists - EDP technologists and information scientists - who are professionally involved in the theory and practice of automated information processing. Conferences for these two groups deliberately designed to study the problems of applying EDP to education will help, as will the mutual provision of opportunities to become more closely involved in each other's work. Both groups must exercise profound patience in struggling with differences in viewpoint and the semantic difficulties encountered in seeking to clarify these differences. But the phenomena of education are sufficiently challenging and provocative to bring able information scientists into needed research and development as avenues of communication increasingly open.

The most promising channels for research and development in educational EDP lie in determining those basic items of information which might constitute cooperative data processing systems, in standardizing nomenclature and definitions, in providing for system and sub-system compatibility, in resolving the interface problems between educational processes and technological processes (including the training of personnel to effect this interface), in investigating the potentiality of automation as an aid to educational innovation and experimentation, in studying and effecting instructional decisions, and in demonstrating tested procedures which might serve as models. These possibilities suggest tremendous geographic spread - from a single local school to a cooperative venture possibly embracing many states - and as equally great spread in amount of data potentially involved. But grant funds must not be distributed according to the physical size of the educational units or the volume of data to be processed. Some small, pilot projects of an experimental sort can be enormously difficult, expensive, and significant.

Fund granting agencies, in considering requests for financial support, are urged to look for the significance of a given project to education, relevance to a wide range of applications, the potential removal of persistent roadblocks, possibilities for dissemination and replication, potentially cumulative contributions to knowledge, possibilities for maximizing scarce resources, appropriate provision for field-testing, contributions to efficiency, and possibilities for self-sustainment. This is by no means an exhaustive list. Nor are such criteria meaningful apart from the specific substance of recommendations for research and development such as those presented in this report. Taken together, however, these criteria and recommendations may prove helpful in deciding among proposals.

Fears that automation will bring into education the anonymity and dehumanization now apparent in many aspects of daily life - even fear of manipulation of individuals by robots - exist in many minds. Such fears are important in that they exist and must be

reckoned with. They are not new in civilization. To dispel them, man must look inside himself, not computers. The computer has no mechanism of self-interest; man does. And so it is to the passions, inflexibility, and ignorance of man that we must look for the realization of our fears, just as we must look to his selflessness, adaptability, and wisdom for the fulfillment of our dreams.

In a special issue devoted to the triumphs and tragedies of the twentieth century, Look magazine (January 12, 1965) succinctly summarizes the fear: "... that modern business will, in ruthless use of its brave new tools, bring a forced idleness for millions and a whole new variety of inhumanities;" and the hope: "The system that we are shaping, and that is shaping us, does more than pile up an abundance of goods. We seem to be driving ourselves, at electron speed, toward a society in which robots are the slaves, and man works at the difficult arts of civilization. If so, America may at last build what it promised itself 178 years ago: a nation in which each sovereign citizen pursues to the limit his human potential."

Viewed pessimistically or optimistically, the kind of world in which we are to live is to be a significantly automated one in which much of education, too, will be automated. But the essence of education which truly sets the spirit free promises to be so essentially human, individual and elusive as to defy any and all efforts to translate it into terms that can be determined by computers.

APPENDIX A

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APPENDIX B

ELECTRONIC DATA PROCESSING IN EDUCATION: THE STATE-OF-THE-ART

The substantive interests of EDP's diverse applications are conceptualized in five broad areas: (1) general business accounting for schools, (2) student accounting for schools, (3) general administration for school systems, (4) automating school instructional programs, and (5) student instruction in computer-oriented mathematics and data processing technology.

The functional interests of EDP users, designers and managers are conceptualized in six broad areas: (1) hardware design and use, (2) software design and use, (3) use of facilities, (4) inter-system flow of information, (5) education and training for EDP in education, and (6) organizations, associations, and agencies for the promotion of EDP in education.

A look into the possible future of EDP in education concludes this appendix.

SUBSTANTIVE EDP INTERESTS

Though still limited in scope, EDP is already demonstrating utility in many information processing functions in education. Most of the applications have been confined to the processing of numerical data associated with business records, student personnel records and reports, logistic control and maintenance problems, and the scheduling and registration of students. Research and development have been primarily concerned with system analysis to improve and integrate conventional data processing procedures. Within the last five years, research and development activities have given some attention to the support of innovations in instructional methodology. These activities include developments in optical scanning devices, language translation machines, computer-assisted instructional systems, rapid document retrieval systems, and computer models of school system operations.

1. General Business Accounting for Schools

California resembles other states with respect to the way school districts initiated their use of EDP. In a report of a statewide study of pupil personnel data processing in California, Grossman (1962) points out that many school districts began with payroll functions and proceeded to accounts payable. After developing their business accounting, they began to consider student accounting.

This route is often taken because EDP applications in the business world are developed and readily adaptable to business accounting in school systems.

At the time of Grossman's survey, approximately 75 percent of the responding county and local school districts were using their EDP equipment for one or more areas of school business accounting. In his survey, business accounting included accounts payable, budget, cafeteria, cost analysis, equipment inventory, payroll, purchasing, retirement, and transportation.

Perhaps one of the best illustrations of the state-of-the-art in school EDP business accounting is found in the Chicago, Illinois public schools. Stanley R. Patton, Director of the Bureau of Data Processing for Chicago schools, reports (1963) that his data processing staff is grouped within six major projects: (1) budget and finance, (2) personnel and payroll, (3) materials, (4) student accounting and student scheduling, (5) education, and (6) research.

Through the use of an IBM 305 Ramac system, a variety of accounting functions is performed electronically for the Chicago schools. The system provides on a monthly basis all expenditure journal entries for the general ledger and produces a "status of accounts" report which depicts the financial condition of each school or administrative unit - information which was not available under the previous manual system. Plans for mid-1964 expansion of EDP include revenue accounting. Patton anticipates that this service, added to their expenditure accounting operations will provide them with complete general ledger accounting and the ability to produce a balance sheet shortly after the close of each month.

Personnel accounting (e.g., records of hiring, managing, and reimbursing teachers and civil service employees) is also a part of EDP operations in Chicago. Teacher payroll, now processed on a small computer, will be done eventually on a large magnetic tape computer system.

The Materials Project for the Chicago schools encompasses the areas of supplies, transportation, communications, purchasing, maintenance and repair, property control, plant engineering, lunchrooms, and textbooks. The information needs of this project have been studied and an integrated plan prepared for EDP processing. Six warehouse and supply catalogues have been codified and put into machine sensible form. Patton reports that the supplies subsystem will determine what, when, how much, and where to stock. The computer will produce picking and packing lists for the warehouse according to delivery schedules, and stock reorders will be automatically issued as any item reaches its order point.

The objective of this effort to apply EDP technology to school business accounting says Patton, is to reduce administrative and clerical costs so that a greater share of available funds may be applied to instruction.

2. Student Accounting for Schools

Unlike school business accounting, student accounting procedures have had very little to draw upon from the well-established area of commercial machine accounting. Furthermore, the variety of requirements from district to district has prevented a rapid widespread adoption of the successful procedures that have evolved. Thus there is great diversity with independent experimental and developmental activities being conducted in a great number of the districts of the country. Student accounting requires a substantially different kind of personnel than that required in the adaptation of commercial business office accounting. Imagination, verbal facility, and understanding of the education world are characteristics of the successful system designer in student accounting. Thorough grounding in machine accounting is a less important asset.

Many universities were early users of punched card methods for maintaining student records. The concentration of large numbers of students under a single

administration and the expenditure of relatively large sums of money per student probably affected an earlier introduction of such methods at universities. Also of significance was the ease with which procedures could be used that required the intelligent cooperation of students.

At the secondary school level student accounting applications were generally a later application of equipment that had already been justified for business office applications. However, Los Angeles was using such methods in handling test data in the 1920's, and Pasadena was developing punched cards as early as 1942. In 1947 Herbert Popenoe reported for the Los Angeles district that in addition to the handling of test data, the Accounting Machines Services Section compiled reports such as:

- (1) Pupil accident reports
- (2) Pupil work permit reports
- (3) Pupil absence reports
- (4) Pupil accounting reports
- (5) Movie permit reports

Today an advanced installation gives much more comprehensive service to student accounting. For example, Broward County (Ft. Lauderdale, Florida), in addition to attendance accounting and a testing program, reports sixteen areas of service under the heading "Pupil Records."

- | | |
|--|------------------------------|
| (1) Student Schedules | By Semester and Year |
| (2) Teacher Schedules | By Semester |
| (3) Class Rolls | By Semester |
| (4) Locator Cards | By Semester |
| (5) Welfare and Attendance Cards | By Semester |
| (6) Library Labels | Annually |
| (7) Attendance Cards | By Semester and as required |
| (8) Student Rosters | By Semester and as required |
| (9) Teachers' Grade Audit Sheets | By Six Weeks |
| (10) Progress Report (Report Cards) | By Six Weeks |
| (11) Teacher's Class Loads | By Semester |
| (12) Permanent Records Labels | Semester and Annually |
| (13) Current and Cumulative GPA
(Grade Point Average) | Six Weeks, Semester and Year |

- (14) Special Reports including locker assignments, bus rosters, ranking reports, graduation listings, assembly seat assignments, grade distributions.
- (15) Computer Scheduling - Pilot Program
Presently, programming approximately 23,500 students in 7 Senior High Schools and 4 Junior High Schools
- (16) Junior College of Broward County
Student Records for 2,100 students

The technological problems of computer aids in the assignment of students to conflict-free schedules have been solved to the extent that almost all high schools of over 1,000 students could be substantially aided by available methods which few schools have as yet tried, largely because few educators have acquired the skills which could assure them a successful trial.

As previously described in Chapter Two of this report, recent breakthroughs at Stanford University, M.I.T., and the University of Pittsburg indicate that operational computer systems for making the master schedule itself, together with diagnostic materials to evaluate possible alternatives, will be available in the near future.

Student cumulative file maintenance and abstraction using magnetic discs are being explored at Palo Alto and, using discs and tape, at Ft. Lauderdale, Florida.

3. General Administration for School Systems

Data for decision making in the general administration of the school system (i.e., the over-all regulation, direction and control of students, employees and facilities in accordance with policies and practices specified by local, district, state and national school administrative systems) are not yet a major contribution of educational data processing centers.

There are many EDP applications which can make substantial contributions toward solutions of the school administration's most serious problems. For example, a census of school and preschool children within various school boundaries can aid in the determination of school attendance and bus-service boundaries, location of new construction, and characteristics of needed facilities and services.

Optimization of bus routes under various safety constraints (such as a low number of crossings of railroad tracks) may indicate bus and driver requirements.

Simulation of master schedules of proposed schools to determine architectural specifications calls attention to faculty needs.

At the state level the cost effect of different apportionment and state-aid formulae can now be determined in a matter of minutes.

Decisions are not entirely simplified because new vistas are also opened up. Some decisions that could previously be easily ignored must now be faced. The very existence of computer technology removes critical impediments to the implementation

of modular scheduling, the continuous progress school, and the coupling of team teaching with single section courses.

4. Automating School Instructional Programs

The application of data processing technology to the functions of teachers, counselors, and librarians has been confined primarily to the streamlining of grade reporting, library accounting and inventory systems, and scheduling work. By saving time on these bookkeeping tasks, librarians, teachers and counselors can give more attention to their students. Some school libraries have automated checkout and catalogue searching procedures in combination with the production of periodic listings of new acquisitions. Improved efficiency and convenience for the student has resulted.

Unfortunately, the developments in computer-based teaching machines, document abstracting and retrieval systems, computer-mediated business and economic games, and computer-linked teletypewriter stations have not been used to any great extent in the schools or universities. This work remains the primary concern of researchers working in laboratories and field installations throughout the country. Here and there, however, can be found occasional applications to ongoing programs in more or less conventional school settings. The small computers made available to the high schools of the Oakland (California) public schools will be used for instructional purposes, both in computer-related subjects and in support of simulated business games.

Several major universities have installed computer-linked typewriter input stations in classrooms and laboratories for faculty and students. These stations are being used to solve mathematical problems, recovering factual data, and checking out computer programs. The Western Reserve University Center for Documentation and Communication Research is recovering research data and source articles for students and professionals in the fields of metallurgy, inorganic chemistry, physics, mechanical engineering, and medicine. However, there is not yet a widespread trend toward the application of data processing technology to instructional functions. The trend is more evident in the interest of researchers than in practical application.

5. Student Instruction in Computer-Oriented Mathematics and Data Processing Technology

There are some school districts that are justifying the purchase or rental of a small or medium sized computer system for the primary purpose of using the computer as an instructional tool in the teaching of mathematics, programming, computer system operation and maintenance, and related curricula. Since the advent of problem-oriented computer languages, even young students can acquire the programming skills necessary to enable them to use the computer in a variety of subject areas. The use of mathematical models, heretofore unavailable to the secondary student, has now become possible for schools with access to computing facilities. By using the computer as an instructional device, the students gain a better understanding of problem analysis and become grounded in computing skills through first hand experience with the machines. In a "Report from a Conference on Computer Oriented Mathematics and the Secondary School," sponsored by the National Council of Teachers of Mathematics, more than fifty schools were mentioned as having concentrated courses ranging from traditional applications (e.g., trigonometry, simultaneous equations) to mathematical research and advanced puzzle problems (Gruenberger, 1963).

This current movement toward computing education in the secondary schools began in, and has since been stimulated by, the colleges and universities. The demand for trained students in electronic data processing, engineering, business machine operations, and related fields has stimulated colleges and universities to adopt an updated curriculum and to expand computing facilities.

The trend in many institutions has been toward "open shop" computing centers available for the use of both faculty and students in any discipline. With the teletype-writing stations linked to the computing center, classrooms and laboratories become substations for program checkout and problem solving. Excellent examples of both the open computing center and the teletypewriter stations may be found at M.I.T., Stanford University, and the University of Oklahoma.

Forty-five colleges and universities with data processing course offerings for both secondary school teachers and students are listed in the Project on Information Processing Newsletter (November, 1963). Only a few offer instruction related specifically to educational data processing.

Following acceptance in the colleges and universities, data processing instruction has been introduced into the programs of technical and vocational high school, post-high school, and adult training institutions. Through support from Title VIII of the National Defense Education Act, many states have developed educational programs for training individuals to become skilled EDP technicians. Training in key punch operations, the wiring of unit record equipment, computer programming, and system analysis are typical courses. The President's panel on Scientific and Technical Manpower reported that 69,000 data processing technicians will be needed annually over the next decade and only about 25,000 are entering the labor force each year (Phillips, 1964). The bulletin available from the U. S. Government Printing Office (1962) entitled Employment Outlook for Careers in Electronic Data Processing and the pamphlet Electronic Computer Operating Personnel and for Programmers released by the National Science Teachers Association (1962) are both valuable references for counseling and guidance personnel and a source of factual material to justify this development. Examples of vocational training programs which include extensive courses in data processing are the courses offered in the ten centers and schools throughout the state of Washington, the Iowa Technical Education Center in Ottumwa, and the long established program at the Dobbins Technical High School in Philadelphia. A directory of Schools Conducting Title VIII Preparatory or Extension Data Processing Technology Courses may be obtained from the Director of the Technical Education Branch at the U. S. Office of Education. Also available from the same office is a Technical Education Series curriculum outline for a two-year course in post-high school instruction in programming and business applications.

To better prepare high school students for technical training or college courses in which use is made of the computer, secondary school administrators and teachers have begun to follow the lead of the technical schools and the universities. Kits of material for ninth-grade general science classes which include theory, operations, and uses of electronic computers have become available from the Project on Information Processing of the National Science Teachers Association at Montclair State College in New Jersey. An introduction to instruction in computer-oriented mathematics for secondary school teachers is available from the National Council of Teachers of Mathematics. Course materials and assistance in establishing instructional programs in

local schools are available from local chapters of the Association for Computing Machinery (ACM) and from the Data Processing Management Association who have a special program for "Future Data Processors."

In summarizing this rapid development of computer instruction within the secondary schools, Harry L. Phillips of the U. S. Office of Education in a paper delivered at the AASA Convention in Atlantic City, New Jersey, (1964) said:

The computer as an instructional device in science and mathematics programs in secondary schools has had a colorful and rapidly developing history. This has ranged from a very sophisticated rigorous mathematical approach such as is employed by Dr. Irving Dodes at the Bronx High School of Science where the students have ready access to a very elaborate computing facility to a program in which Professor Richard V. Andree, at the University of Oklahoma, has transported students as far as 300 miles to involve them in a Saturday computer education course in Norman, Oklahoma. (Significant computer oriented instructional programs are being developed in the Greater Philadelphia area, Chicago, Detroit, Des Moines, Washington, D. C., Boston, Buffalo, Seattle, Palo Alto, Minneapolis-St. Paul, Pittsburgh, Miami, Norman, Oklahoma, New York City, and many other localities.)

The fact that there has been a scarcity of secondary school teachers who are prepared to teach computer mathematics courses has been a major problem. Some progress is being made, however. The National Science Foundation and Title VIII of the NDEA Act sponsor summer institute programs across the country for training teachers.

FUNCTIONAL EDP INTERESTS

The functional interests of educational EDP users, designers, and managers are reflected in their research, development, and operational programs. Another important source of information is found in their professional organization activities. In seminars, workshops, annual professional meetings, and publications, they treat issues and problems of considerable breadth and scope. They draw heavily upon related fields, such as computer programming and engineering technology; system analysis and design methodology; operational research practices; and educational research, development, theory, and practice.

1. Hardware Design and Use

Electronic data processing hardware has developed so rapidly from such relatively recent origins and with such diversity that this report deals with it only in a very general way. Comprehensive texts are available which describe various types of hardware and their use. In general, hardware of major interest in education falls into three categories: Simple punched card equipment, also called unit record or EAM (electric accounting machines), digital computers, and accessories.

Simple punched card equipment was in use before 1900 in the United States and in Europe, but it began to be widely available only after World War I. The keypunch

punches holes in cards; it may also print along the upper edges of cards. Sorters are used to arrange punched cards in order and/or to count or select them. Reproducers are used principally to copy all or portions of the contents of cards or as an output device for other machines. Collators are used to merge or select cards, to match sets of cards, to check sequences, and for other editing work. Tabulators are printing devices, capable of printing entire lines of type at rates varying from 50 to 150 lines per minute; most are equipped with simple logical and arithmetic units which permit some selective treatment of the cards and simple operations on the data punched in them. Interpreters are used to print pre-punched data directly on cards for ease in handling.

An electric accounting machine, though simple compared to a computer, is a complex of many independently controllable functional units. For example, the units within the Accounting Machine control the movement of punched cards; read punched holes; recognize special cards and the boundaries between groups of cards; add, subtract, and compare numerical data; and print information.

Only by making appropriate electrical connections can the user combine these units into a special purpose machine capable of performing a required task. Some connections are made so frequently that external switches are provided. However, switches cannot be installed for the millions of potential connections. These may be made on a control panel, commonly known as a plug board. Though simple in structure, the control panel serves as the nerve center of the machine. It is a frame for holding the contact ends of wires in fixed positions so that an assemblage of thousands of wires may be clamped to the machine to complete appropriate electrical circuits.

Electric accounting machines are simple to operate, but the design of control functions is rigid, tedious, and complex for some of them. Their cost varies, depending on speed and capacity, but they are within the reach of all but the smallest or poorest school districts. Many EAM units are necessary or useful as accessories to computers.

Computers vary in size and capacity from simple devices which may be carried about by hand and plugged into any ordinary wall outlet to very large configurations involving many interconnected units, with extensive air conditioning and/or special power sources, and some of them require thousands of square feet of floor space. The earliest digital computers, of which few remain, were electromechanical -- i.e., they used wheels, levers, and rods activated by electric power. The first truly electronic computers used tubes and hence generated a large amount of heat. The most widely applied computers today use cooler solid state devices such as transistors and hence require less air conditioning. The computer may use punched cards for input or output but is distinguished from punched card machines principally in that its processes are controlled by an internal program -- a sequential set of instructions which the computer stores and then acts upon according to a predetermined logic; since these instructions are coded as numbers, they may be modified by the computer itself in precisely controlled ways. Computer programs must be written so as to take account of every foreseeable event or contingency. The task of writing computer programs requires attention to such a mass of detail that programmers have devised special programs which help them write still other programs.

Computers operate at very high speeds and hence at a very low cost per unit of work. One of the principal considerations in determining whether to use a computer rather than punched card equipment is the amount of work which must be done in a given time. A process requiring 8 hours of EAM work may be done on a given computer in 8 minutes. But it is not economical to acquire a computer if it is to be used only 8 minutes a day.

Accessory devices include card-handling equipment (trays, trucks, racks), storage (for cards, documents, control panels, magnetic tapes, wires for the panels), and paper-handling devices (for feeding and collating forms, separating and decollating them and printing vertical lines on tables). The latter are usually purchased, whereas most but not all EAM units and computers are rented or leased.

Test scoring machines constitute a special class of accessory devices. The most widely used, the IBM 805, is actually a computer: It compares marks on a test answer sheet with a key pattern, measures the resistance to electric current in marks properly made, and translates the results to the movement of a needle on a visible dial. The operator notes and records the position of this needle. In the last decade, several optical systems have been devised. These use variations in light intensity caused by the presence or absence of marks in pre-specified positions. The larger of these devices (e.g., at the Measurement Research Center, University of Iowa, and at Educational Testing Service, Princeton, N. J.) permit automatic feeding and handling of the input documents and produce output which can either be punched in cards for later printing, or transmitted directly to magnetic tape or to the storage system of a computer. As document-reading devices are perfected that can read and translate handwritten letters and numbers, additional uses will be found for these large special-purpose machines; for example, attendance accounting, grade-reporting, questionnaire analysis, and work or performance records.

The cost and performance characteristics of computers are directly affected by the type and number of specialized units incorporated in any particular system. The "heart" of a computer is its logical control and processing unit. At any moment, input may come from a manual keyboard or typewriter, a punched card or punched paper tape reader, a magnetic tape unit, another computer, or an optical reading device. Output units may be of the same type, with the exception that a card punch would be used rather than a card reader, and with the possible addition of visual or auditory display devices. Storage devices include spinning drums or discs, magnetic tapes, electronic tubes, and ferrite cores (small rings of metal enmeshed in a matrix of connecting wires). Newer ways of storing data are under development; e.g., methods which exploit the molecular structure of special compounds.

What Configurations are Readily Adaptable to Future Needs? Most data processing installations evolve by adaptation to changing needs and capacities. Few maintain the same configuration more than two years and very few more than three years. Thus the evaluation of a particular configuration must include consideration of its adaptability to growth through change which is minimally disruptive--change which necessitates small loss in previous software--change which increases flexibility.

The move from EAM equipment to a computer is a special exception. It is often extremely disruptive. However, disruption may be tolerated because of the very great increase in the capabilities and efficiency of the computer installation.

The usual growth in power of a small installation comes through the addition of a different machine type. Will such a new configuration be a truly powerful one for its size? Or will it have fundamental weaknesses inherent in its having grown without adequate foresight? Just as the older configuration has to be chosen primarily to assure capacity to perform the tasks which justify the expenses of the installation, the new configuration has to be based on the anticipated tasks. Unfortunately these problems can be only dimly perceived from two or three years away. Furthermore, it is frequently unwise to allow future planning to be excessively restricted by this scarcity of specifics. Even the man who has to dig a post-hole may be much wiser to buy a shovel--a general purpose digging tool--than to buy a post-hole digger.

Fortunately, a clear path can be traced through this maze, assuming no freakish local circumstances, and may be safely followed. For each different size of small installation in educational data processing, there is a popular configuration. In each case it may be found by adding a single machine type to the next smaller configuration, which then stands ready for equally simple expansion to the next larger level (see Table 1). This sequence is as follows: keypunch, sorter, accounting machine, reproducer, collator, interpreter. Beyond this rather complete installation, the path becomes dimmer. The next preferred machine, the test scoring machine, can be added at any time. Centers electing any of the smaller configurations can at least be added at any time. Centers selecting any of the smaller configurations can at least be assured that many educational applications may be performed.

Adding a computer to the configuration, usually because of growing recognition of increasing work loads which cannot be met by an existing machine group, always seems a very serious step. Not only does cost mount sharply, but some elements of the EAM configuration have to be retained for support (e.g., the keypunch). The true test of the necessity for a computer is the question: what will the computer permit us to do which we cannot now do with comparable efficiency, or merely by increasing the number of hours of EAM utilization?

2. Software Design and Use

In the world of EDP technology, the term hardware has a fairly well-understood meaning: It designates machines, computers, and accessory devices. However, the term software is the subject of debate. It is sometimes loosely used to designate "all that is not hardware." The writers of this report use the term to designate computer programs (whether listed on paper, punched in cards, or recorded on magnetic tape) and their documentation; written descriptions of manual and machine procedures; input and output forms and formats; coding systems and layouts; and drawings or other representations of wiring diagrams and flowcharts.

A punched card installation is sufficiently different from a computer installation to warrant separate software discussion for each.

a. Software in the Punched Card Installation

Guidance and control of data through a punched card installation has been a major problem. Costly and continuing personnel time is required in this area. This places on the center staff a large responsibility for job description, recruitment,

TABLE 1

**POPULAR PUNCHED CARD EQUIPMENT CONFIGURATIONS OF VARIOUS SIZES*
(COMPUTER INSTALLATIONS NOT INCLUDED)**

<u>Number of Different Types of Equipment Installed</u>	<u>Number of Respondents</u>	<u>Most Popular Configuration</u>		
		<u>Description</u>	<u>Number</u>	<u>Percent</u>
1	4	Keypunch	3	75
2	5	Above, plus Sorter	5	100
3	21	Above, plus Accounting Machine	16	76
4	11	Above, plus Reproducer	8	73
5	26	Above, plus Collator	16	62
6	16	Above, plus Interpreter	8	50
7	15	Above, plus Scoring Machine	7	47

*Calculated from data reported in L. R. Reed, Data Processing Systems, May 1963, privately reproduced (hctograph). Of 288 known educational data processing centers, 225 were queried (including all outside of California), eliciting 165 responses.

training, and retraining. Many centers have suffered woefully from under-estimation of their personnel needs. Understaffed centers suffer from insufficient and inefficient machine utilization, from inadequate documentation, expensive job pick-ups (transfer of jobs from operator to operator), and difficulties in training new personnel. Such installations build excessive dependencies on the individual who must carry much of the necessary software knowledge in his head.

The data processing installation does a variety of jobs, many rarely done exactly the same way on successive occasions, many recurring only on a long time cycle. In a punched card installation this demands a great number of variously wired plug boards.

The number of plug boards needed is usually underestimated by the salesman attempting to install an EDP system at an acceptable cost and even underestimated by a supervisor previously experienced only in the conventional commercial installation. The Richmond, California school installation had over fifty 407 plug boards, but this number of boards is unusually high; most EAM installations struggle along with 10 to 20.

Punched card installations with an inadequate number of plug boards lose much time in tearing down and rewiring boards for less frequently recurring jobs. Much of this time involves expensive personnel.

Punched card guidance and control may be categorized in two broad areas: (1) procedures concerned mostly with the sequence and details of manipulations of punched card decks and, (2) plug boards. The first area is--and has to be--generally better documented. Operators with little training must be able to pick up a recurring job previously done under close supervision only once or twice. This condition requires explicit, written instructions which can be omitted only at the expense of close, continual supervision.

Plug boards are rarely well documented. There is often little internal need, and boards for recurring jobs are generally wired permanently. The very expensive job of diagramming is sometimes actually deemed an extravagance.

Diagrams or other notation are needed for boards which must be rewired. The decision to tear down a board involves an evaluation of the difficulty or rewiring, including the preparation of the necessary documentation and an estimation of the probabilities of having to rewire within given intervals of time. The crude diagrams used internally are rarely of any value to an outsider. Generally color-coded, they do not reproduce well. Idiosyncratically notated, they are largely meaningless except to the author. Hence there is very little transmittal of sophisticated plug board software from installation to installation. Similarly, many procedures are worthless without documentation of the basic plug boards. Obscure journals occasionally publish an article which includes a board diagram. Manufacturers have published some monographs with board diagrams. Several volumes of Educational Research Forum Proceedings represented an early attempt by IBM to meet needs in this area. Many ingenious but now outmoded early software developments were never well disseminated. An example is Educational Testing Service's factor analysis techniques using a conventional IBM tabulator; another is an elaborate punched card method of assigning secondary students to class sections in Huntington Beach, California. Indeed, generally unknown were the

possibilities of using the tabulator to compute percentiles or sums of squares and cross-products for correlation calculations; these so-called progressive digitizing techniques were never widely understood. A few installations had tabulator plug boards for producing graphs and scattergrams.

Sophisticated punch card software is now being replaced by the computer just as surely as metal tools replaced highly developed bone and stone tool techniques. Elaborate and often highly ingenious early punched card methods could only be justified when more economical computer facilities were not readily available.

The difficulties of developing widely usable software at the punched card level results in a very slow rate of "lore diffusion," forcing each installation to be its own research and development center. The only communality one can be sure of finding is the wealth of unwritten experience in the minds and fingers of the operators and supervisors trained on the job in commercial installations.

b. Software in the Computer Installation

With the advent and wide availability of the computer came a substantial change. Basic control no longer rests in an expensive wired plug board, hard to store, hard to reproduce. Control functions are now replaced by an inexpensive, easily stored reproducible program in the medium of punched cards, paper tape, or magnetic tape. Procedures describing elaborate card handling procedures are obviated by the manipulation of the data within the computer itself, entirely under the control of a self-monitoring program. An installation with a small computer can generally go into operation immediately, using borrowed programs in compatible input formats.

The programs themselves are written in one of several understood languages which permit relatively easy local modifications. It is now possible for a few centers or institutions, such as NEEDS (New England Educational Data Systems, at Harvard University) or the State of California Research and Development Center at Sacramento, to be the source of many programs used throughout the country.* It is indeed fortunate that the relative ease of transmittal and exchange of software makes it possible for installations to draw on each other's resources, because software is the most serious and expensive obstacle in the development of a computer installation. Computers can be used more than half of their time assisting in the writing of their own programs, but the ratio of program development time to operation time is still forbidding, especially in early stages of computer utilization.

The cost of software development and maintenance affects the total operating cost of a computer installation. These costs in turn are very much affected by the quality and quantity of software provided by the manufacturer. The latter generally provides the compilers that make possible the use of the variants of the major programming languages. One may expect the manufacturer to offer a library of utility programs and subroutines that greatly simplify programming. There is also a system of maintaining

*For more details concerning these programs, see Chapter Two and Appendix C of this report.

an annotated catalog of programs available through a cooperating organization of users. Some manufacturers managed to get a substantial head start in the software area by installing computers in the universities and developing strong cooperative users groups. Other manufacturers have met the need by making very heavy expenditures in their own software development departments.

Programming personnel are still in short supply, especially at any distance from large metropolitan centers. In even shorter supply are programmers who understand educational statistics, educational data processing, educational jargon, and educational human factors. Lacking such personnel, it is necessary to have on the EDP center staff an educator who understands computer technology sufficiently well to define an educational problem in terms the programmer can handle. Fortunately, the work of good programmers, when well documented, can be exchanged and disseminated at low cost.

c. Input and Output Forms and Designs

There are two large classes into which most forms used to transmit information may be divided: internal and external. Internal forms are used either by the EDP system staff for its own work or as the input to a machine. For example, a punched card which is to be handled only by experienced EDP personnel need have no form printed on it at all; the operator can look at a card layout guide and can interpret readily what the holes signify. If an EDP system uses punched cards on which the codes appear, it does so for convenience and for checking purposes.

External forms are designed either to collect or to display information. For example, if a teacher is to make marks on a document which will later be mechanically processed, and if these marks are made with reference to particular students, the form must show the identity of the students and the exact nature of the marks or entries to be made. The form must be uncluttered, unambiguous, and readable, to reduce the chance of erroneous use. The other major class of external forms contains those which display information to parents, pupils, and school personnel; for example, report cards, test results, attendance summaries, transcripts of records, recommended classifications, test data profiles, and correlation scattergrams. Experience shows that such output documents must emphasize clarity of presentation. Secondary emphasis is given to esthetic value and to such mundane matters as whether the size of the documents fits a particular envelope or filing drawer.

Design of internal forms is usually left to the discretion of the EDP staff. Design of external forms is usually accomplished, under the best conditions, by a combined team of EDP specialists and those who will process the forms. In most cases, the EDP specialist begins with the old forms from a manual system and designs several alternative forms for machine processing. He then works with the educator in selecting, modifying, and combining the elements.

Veteran EDP specialists in school systems report that it is very valuable to consult all school personnel who have any concern with forms. The specialist may design a perfectly logical and usable form all by himself, but the educator usually has new ideas, suggestions, and purposes which he may have waited a long time to advance. Furthermore, it is good practice to involve the educator in all possible phases of EDP system design, and the forms which will be used for input and output of information constitute the principal contact the educator will have with the new system.

One feature of the evolution of EDP systems in schools which has received comment is the multiplicity of forms designed for similar purposes. On visits to a variety of school systems, specialists may collect a hundred different report card forms from a hundred different districts, most of them differing only in very small details or in arrangement. In the early history of the CPGA (Cooperative Plan for Guidance and Admission) in Georgia, analysis of such proliferating forms showed that more than 90 percent of the items were identical in purpose and content; disagreements were often matters of trivia; whether to say "boy/girl" or "male/female," or whether to state age in years and months or only in months. Real disagreements about content pertain to local concerns which can be accommodated in widely used forms by permitting optional use of certain items.

In addition to the apparent confusion of large numbers of different forms designed for similar purposes, there is the question of cost. New forms usually involve design, plate-engraving, composition, or set-up charges. In California, some school districts which agree on common use of certain card forms find that they can reduce costs by mass purchasing through a single agency.

However, costs and confusion aside, it seems certain that it will be a long time before the means or the motives can be found to bring all school systems to accept the desirability of surrendering local interest to common regulation. And the cost involved is not so great that local initiative should be balked until agreements can be reached. In the opinion of most EDP practitioners, it is a shame that general agreement cannot be reached, but meanwhile school systems must move ahead. The achievement of local objectives is more important than minor gains in widespread efficiency. Again, as in the case of inter-system cooperation, the answer is compatibility rather than uniformity.

3. Use of Facilities

The beginning question in the design of any facility for data processing concerns the extent and nature of its utilization, and this question will be asked repeatedly in varying forms as the system and the installation evolve together. There are some subtle issues involved which do not make immediate sense to hard-nosed accountants and budget-watchers. But it may be asserted with some confidence that everyone concerned with facility utilization has at least one common purpose: full and effective utilization.

The term "full utilization" is not self-evidently defined. For example, in one county installation it was noted from work records that an IBM collator was used only 20 percent of the available day shift time, and word was passed down to discontinue its rental. Analysis of the foreseeable consequences of such an apparent economy move showed that the work done by the collator in that 20 percent period would require the manual labor of two clerks at roughly five times the cost of the monthly rental of the collator. The point is that "fullness" cannot be judged entirely from percentage utilization.

The history of most EDP and computer installations shows that in the early period of acquisition of any piece of equipment it does not usually receive full utilization, in any sense. Gradually as work expands and the device is integrated with the system, a point is reached at which the device is being used to capacity. If the load increases, as it always seems to, another point is reached at which the inability of the device to accept

a heavier load seriously affects other processes in the system. For example, if a printing machine running at the speed of 50 lines per minute cannot produce desired reports in a necessary time limit, even by running the device all the time, a faster one must be obtained. An additional one may not be the answer if the processes cannot be divided into parallel lines. As soon as a faster printer is obtained, say one operating at 150 lines a minute, it may be found that the work required can be done in much less than a full module of time, and it may then appear that the new printer sits idle part of the day. However, this condition will not last long. History shows few examples of failure on the part of EDP personnel to find new work for their machines.

Most facilities expand at a rate slower than their load. In almost every installation one may visit, one finds that faster, larger, or more powerful devices are on order, usually for delivery at a much later date. And such orders were usually placed only after the overload on the existing system had already become painfully evident to everyone, except the administrator responsible for approving acquisition of the new--and usually additional or more expensive--device. Fortunately, EDP personnel become adept at planning their work around such difficulties. They use external service bureau facilities; they scrounge, borrow, or buy time from other installations during off hours or periods of diminished load; they work overtime or run the machines into the night and on weekends. They may even quietly place orders or letters of intent to order, long before official approval has been obtained. In some cases, equipment ordered today may not be deliverable for many months--sometimes more than a year. Hence, it is reported by seasoned EDP specialists that many orders are placed in the hope of subsequent approval in time to accept delivery--and in the knowledge that if worst comes to worst, delivery may be delayed or cancelled.

The use of service bureau or other external facilities is often an alternative or supplement to acquisition of one's own equipment. There are two considerations reported by those experienced with this problem: It is obviously cheaper to use equipment on a part-time basis if one needs it only part of the time. As soon as the cost of using service bureau equipment approaches the cost of having one's own equipment, the switch may be made. However, if the external equipment is located at any distance, or if it may be used only at inconvenient or impractical hours, cost estimates must include the personnel time required for travel or for overtime assignment.

The most important part of this second consideration, however, is the extent to which the entire EDP system may be affected by delays in processing, or by insufficient opportunity to control the procedure or respond to unexpected emergencies or variations. For example, in one school district which used mark-sense cards for quarterly course reports, the district did not have its own mark-sense device. The incoming cards, after minor clerical editing, had to be boxed and then transported to an external facility where the mark-sense device could be used. The process required that everything else come to a halt until this external phase was finished. When the district eventually acquired its own mark-sense device, the work proceeded more smoothly because the staff could work on other tasks or on other machines while the thousands of grade-reporting cards ground their way through the mark-sensing process. Furthermore, delays in packing, travel, re-packing, and return were eliminated.

The point is that convenience and accessibility, as well as "turn around" time are extremely important. The easiest portions of a process to do on external equipment are

the initial and terminal ones. For example, large keypunching jobs can be farmed out, and final printing of a report can be done remotely or at the point of use.

As facility utilization increases in volume it also generally increases in scope. That is, a greater variety of work is done for more persons and departments. This means that a facility sooner or later faces the problem of whether or not to operate on an "open shop" basis. Ordinarily, EDP equipment is initially acquired by a business office or a research department to do its own work. It later begins to do work for other departments, as time and opportunity permit. Soon these other departments come to depend on such aid, and finally there comes a day when both payroll and report cards must be processed at the same time. Priority will generally be given to the needs of the proprietor or to the department with the greatest political influence. Wise scheduling, of course, can prevent such emergencies in most cases.

However, in all mature installations with which the writers are familiar, the issue eventually has to be faced: How and under whom is the EDP facility to be managed for the good of all departments? An allied issue concerns the amount of decentralization. The experience of EDP specialists has shown, with few exceptions, that the administration of EDP systems should be placed close to the top executive. In a school system, directors of information processing and EDP services who report directly to the superintendent appear to have the most effective, widely admired and accepted systems.

The value of an EDP facility declines roughly as the square of its distance from the user. If it is too difficult or complicated to obtain access to the equipment or to the services, they will not be used to full advantage. Furthermore, the EDP system must integrate diverse interests and activities and serve all segments of the organization with equal care and skill.

The EDP administrator should relate to and be a member of an advisory group which sets priorities on the general nature of work to be done and departments to be served, which plans and reviews the budget for the system, and which evaluates the effectiveness of services provided. It appears to make all the difference between an accepted system and a rejected one to include the consumers and users of the service in some way in the development of policy and program as well as in the evolution of those portions of procedures and regulations which impinge directly on the educational staff. The operation of the EDP system seems most successful when it is made a part of the institution as a whole rather than the empire of a major branch of the institution.

4. Inter-System Flow of Information

A major ideal of any farsighted system designer is to integrate all parts of the system in a logical and efficient pattern of static and moving parts. As EDP methods begin to be adopted in education, anomalies appear which disappoint and baffle the system designer: Transfer students from other districts appear with transcripts, made out originally by a tabulating machine from punched card records, and the contents of the transcript must be re-punched for use in the local EDP system. Test papers, scored by a machine, require additional manual work as the results of machine scoring are punched into cards. Reports sent from local school districts to state departments of education are carefully typed from records printed by a high-speed computer from magnetic tape sources, and the staff of the state department must then re-punch the data for use in their own equipment.

There are many obstacles to the development of procedures which permit one EDP system to communicate with another either by using machine-readable (sometimes called machine-sensible) documents or directly by wire or microwave. Devices which permit functional connections between computers, or between input/output devices and computers, make teleprocessing technically possible. Information stored on magnetic tape may be communicated either by sending the tape or a copy of it or by attaching a tape-handling machine to a teleprocessing unit which permits the owner of a teletype unit to dial a distant computer installation, just as in placing a telephone call, and to obtain access to a computer, using regular telephone lines. Transcripts of records can be communicated on documents scanned by optical devices that convert the contents to a form immediately usable by machine. The cost of teleprocessing is reasonable, the devices are becoming increasingly available and efficient, and the equipment of various manufacturers is beginning to reflect a growing interest in compatibility. Can one logically expect, then, to find educators making use of this technology? With minor exceptions, the answer is no.

The exceptions involve portions of well-understood processes. For example, when a pupil takes a standardized test and indicates his answers on a machine-scorable answer sheet which is then sent to some distant center for scoring, there is minimal inter-system teleprocessing. In the Richmond, California, EDP center, teachers use punched cards to report absences to a central office which uses the cards to make mechanical records. In Georgia and some other states, optically-scanned forms are manually prepared for processing of high school transcripts of college applicants at a distant center in Princeton, New Jersey. The Measurement Research Center in Iowa processes millions of test answer sheets and can return results to schools either on punched card or magnetic tape.

These few instances of inter-system efficiency of communication are less impressive than the gap between the available technology and the use being made of it. Some of the major reasons for believing that such inter-system transmittal will be slow to emerge are: The magnetic tapes used on one manufacturer's equipment may not be usable on another's. Formats (on punched cards and on magnetic tapes) differ from school district to school district, and between schools and colleges. Terminology itself differs; school districts do not use the same names for similar courses or a similar system of coding. Definitions differ widely; it has been observed that legal and administrative differences in attendance accounting definitions and procedures exist among all 50 states. An "A" may be worth 4 points in one system, 5 points in another, or 40 in still a third. Spanish 1 may mean a semester in one system and a year in another. One district uses local norms, another national norms; one uses percentiles, another IQ's, another mental ages, another grade-placements.

Not all inter-system information exchanges require telecommunication or the transmittal of machine-readable documents. The use of central information systems need not bring all of the information to the center itself. The best example of an information system with many remote "nerve endings" is the automated reservation system now used by airlines. Under such a system, it may be possible eventually for a college to interrogate an applicant's high school without actually having the record in its own hands. Much progress has been made, for example, by the College Scholarship Service, which permits scholarship applicants to fill out a single statement of financial condition which is centrally edited and analyzed and which can then furnish information to a variety of potential grantors or colleges. Similarly, instead of taking several entrance

examinations, applicants to College Entrance Examination Board member colleges take a single set of tests, centrally scored and processed, results of which can be sent to any college the applicant designates, or to a scholarship agency in support of an application for aid.

Steps are being taken by the U. S. Office of Education to establish a Basic Educational Data System (BEDS) containing, at first, a few simple facts about every certificated school employee in the nation. BEDS could thus be interrogated for information or, year after year, for research purposes. A state interested in comparing its teachers with those of a neighbor (or with the other 49 states) could thus have access to data of great potential value in the formulation of policy. In the case of BEDS, many states are expected to furnish social security numbers which can be used, in cooperation with the Social Security Administration, for additional studies. This arrangement would permit inter-system data analysis without revealing the identity of any individual between systems.

Although there are few examples of inter-system exchange, plans for such systems are widely discussed and are being studied in research, development, and service centers. As described in Chapter Two of this report, the New England Educational Data System (NEEDS) provides for cooperation between more than 20 school systems and a central cooperative service agency. As time goes by, it will be possible to transmit data about students from one NEEDS school to another as pupils change residence. Such transmittal is a reality in most large school systems in which an EDP system is centralized; that is, when a pupil moves from one school to another within the same school system, his record is altered to show the fact, but his record need not be transmitted anywhere as far as the central EDP data bank is concerned. In Sacramento, California, the Research and Development Center of the State Department of Education is devoting great effort to the development of systems in California and to the problem of exchanging data between schools and the State Department. (See Chapter Two for additional details.) School systems in Florida which have EDP facilities are beginning to make reports to their State Department of Education in machine-readable form. Similarly, schools in California may report results of the mandatory statewide testing program to the state agency in punched card form.

It seems probable, in the opinion of many EDP specialists, that the value of inter-system exchange and transmittal may take a long time to develop to an effective level, but it appears equally probable that the results of such cooperative systems may well be among the most significant. It is here that the greatest potential for cost reduction may lie. And the accessibility of accurate data for states and for the nation as a whole, as a by-product of inter-system transmittal and exchange, may provide a sounder basis for the development of educational policies, programs, and legislation.

5. Education and Training for EDP in Education

As indicated in this report, one of the major recommendations which emerged from the Lake Arrowhead Colloquy was that attention must be devoted to providing the training necessary for educators to understand and use the resources of automation technology. It is the opinion of many computer specialists that every program of general education should include material designed to acquaint all citizens with the nature of computers and what they can and cannot do. The need of the data processing industry for personnel is well known.

But within education itself there are two needs that are not being met adequately. In the first place, all educators need to know more about EDP and its place in education, as well as enough specific information to cooperate intelligently with the system which actually impinges on them. In the second place, there is a great shortage of persons qualified to design, establish, and operate educational data processing systems in school districts. Those now in the field generally learned on the job. As of the winter of 1964, no institution of higher learning offers a complete course of study for professional specialization in educational data processing. A few colleges offer a single course or a summer workshop; and computer programming or EAM operations are taught as separate disciplines in hundreds of schools and colleges.

What is lacking is a curriculum as thorough as that for the school administrator, the psychometrist, the teacher, or even the educational research worker. The scarcity of opportunities to pursue such a course of study continues to be a major obstacle to utilizing the resources of automation technology in education. What little can be learned from occasional short courses or workshops indicates, principally, the inadequacy of such measures. In the opinion of those who have taught such courses, or who have been responsible for training EDP personnel, internships are needed in operating systems. Internship training should include thorough instruction in computer programming, EAM processes, system analysis, facility planning, statistics and research methodology, management methods, and business operation. Lacking such instruction or courses of study, the best that the interested educator can do at present is to pick up a course here and there, read the small but growing literature of the field, and try to obtain on-the-job experience.

6. Organizations, Associations, and Agencies for the Promotion of EDP in Education

Prior to 1961, there were no professional associations primarily concerned with the special problems of educational data processing systems. Educators interested in data processing and data processing specialists interested in education could join the Association for Computing Machinery, the Machine Accountants Association, the Association of School Business Officials, and similar groups concerned primarily with computer hardware and software or with accounting machine applications. National and regional conventions of educational and psychological associations occasionally schedule special interest meetings or symposia on the topic of educational data processing; for example, the American Psychological Association (usually for the benefit of measurement specialists), the American Educational Research Association, the Psychometric Society, and the American Association of School Administrators.

In 1961, a small group of educational data processing specialists in California, meeting with the California Educational Research Association, discovered sufficient interest in data processing to warrant holding a trial statewide convention. This convention met in Los Angeles in November, 1961. It was obvious from the attendance of more than 130 persons that many educators recognized the need for a professional association; hence the California Educational Data Processing Association (CEDPA) was formally founded in the spring of 1962, the first such association in the nation and still one of the largest. Three regional CEDPA subgroups meet in the intervals between annual conventions.

In the fall of 1962, motivated by similar concerns at the national level, a small group of educators from state departments of education, universities, and large school

systems founded the Association for Educational Data Systems (AEDS). This organization held its first annual convention in Washington, D. C., in May, 1963. The AEDS Bulletin published monthly, carries news of professional interest to members of the Association.

Founded originally at Chicago Teachers College North by Murray Tondow, the Educational Data Processing Newsletter appeared in 1960-61, with a very limited initial subscription list. By 1962, at which time Tondow moved to California, the operation of the Newsletter had become too burdensome for a personal effort, and the voluntary staff of the Newsletter established the Educational Systems Corporation (ESC) as a nonprofit educational corporation in California. Representing both national and local organizations on its Board of Directors, ESC now also publishes a Journal and has initiated a series of monographs.

Several other associations have an interest in some major aspect of educational data processing. The Association of School Business Officials led the way in introducing more efficient methods in the business management of schools. The Business Equipment Manufacturers Association, through special subcommittees working jointly with the American Standards Association, represents the educational interests of the major equipment manufacturers. The Data Processing Management Association has established a program of examinations and certification in an effort to encourage professional growth on the part of those engaged in data processing work.

Special interest groups of college and university users of particular computer systems (user groups) have been very active in recent years. The College and University Systems Exchange (CAUSE) and the Machine Records Conference, like other user groups, seek to exchange technical and professional materials and experience. Members of user groups meet periodically for detailed work on specific technical problems.

The need for national coordination of the education data processing interests of professional educational associations became apparent at the same time as the formation of AEDS. Representatives of major associations, most of whom have their headquarters at the NEA Building in Washington, D. C., established a Council for Educational Data Systems in the fall of 1962. Still informal in organization, this Council was established to provide a means for communicating to educators information about developments in educational data systems. In addition, the Council was intended to speak for the educational profession when it needs to represent itself to EDP specialists and manufacturers concerned with technology and system operation.

Greater recognition on the part of state departments of education that educational data systems are of increasing concern to the states and that it is desirable to coordinate state efforts in the national interest, led the Council of Chief State School Officers (CCSSO) to establish, in 1963, a Commission on Educational Data Systems (CEDS). This Commission was charged with the responsibility for conducting studies, formulating recommendations, and planning for development on behalf of the departments of education in the 50 states. A 9-man executive committee represents the CEDS membership between annual meetings of the total Commission and of the CCSSO.

Professional associations for educational data systems have been formed in California, Florida, Colorado, and Texas. Similar actions are contemplated in other states.

FUTURE EDP APPLICATIONS TO EDUCATION

The burgeoning research in the use of the computer as an aid to effective learning reflects a new focus for the application of electronic data processing equipment in education. Heretofore the refinement and extension of conventional practices in pupil-personnel accounting, logistical support, and scheduling requirements held the attention of the great majority of EDP professionals in education. Today, it is the development in computer-based teaching machines, rapid information retrieval systems and the advances in computer technology for aiding teachers and counselors in the diagnosis of student learning needs and in selecting appropriate teaching strategies which seem to hold the attention of researchers. This, of course, is not to say that the problems of the administrator or the business manager are secondary to the problems of the teacher, for only when the superintendent, the principal, and the business office manager make effective decisions based upon accurate intelligence can the school system run smoothly. However, the research in educational data processing with its emphasis on instructional systems gives a broader perspective of computer technology in education.

The Computer in the Classroom

The computer as an aid to effective learning has three basic functions. It serves as: (1) a simulation vehicle for student instruction in decision-making processes, (2) a mediating and controlling element for self-instructional devices or teaching machines, and (3) an information bank aiding in the diagnosis of student learning problems and the prescription of appropriate teaching strategies.

1. A Simulation Vehicle for Student Instruction in Decision-Making Processes

Simulation has been a part of instructional methods at all levels of education for many years. With the use of the digital computer, classroom simulation can increase in realism and complexity. For example, the research staff of the Board of Cooperative Educational Services in Yorktown Heights, New York, has prepared computer-based instructional programs that simulate conditions that promote decision-making skills. One program prepared for sixth grade students provides printed information about the economic conditions of a country with random natural events such as droughts, fires, and plagues. The economic conditions of a five-year period are reduced to fifteen minutes during which time a student is required to make decisions about the planting, storage, and distribution of the country's basic crops. Decisions that have direct and immediate effect upon the economic well-being of the country are typed on a keyboard linked to the computer. The computer in turn responds to the student via a typewritten printout that indicates the effects of the student's decisions.

Another example of computer-based instruction is found in the Yorktown Heights' experimental program in simulated chemical analysis. Seated at a typewriter keyboard linked to a computer, the student directs the computer in a step-by-step chemical analysis. From a desk viewer the student observes the results of each instruction to the computer. If the student orders a mixture of certain chemicals, a colored slide projected onto the viewer shows the reaction of the mixture.

In another setting the computer has been used experimentally to train medical students in diagnostic decision-making. Presented with minimal patient information, a

medical student indicates the steps to be taken in a methodical physical examination of the patient. The student also orders laboratory tests he believes to be appropriate to the case. By typing questions and responses on a computer-linked keyboard, the student and computer carry out a dialogue that serves to demonstrate to the student correct diagnostic procedures.

Unfortunately, decision-making is closely associated with value judgment and it is difficult to get educators to specify objective criteria for the selection of one decision as against another. Although the tools for training in decision-making are well within the state-of-the-art, the educator must take on the responsibility of making a clear and precise statement of the educational objectives involved.

2. A Mediating and Controlling Element for Self-Instructional Devices or Teaching Machines

Certain principles of learning, developed in psychological laboratories and validated in educational practice, have currently been applied with considerable success to the development of new self-instructional textbooks and teaching machines. These principles have been identified with the educational process called "programmed learning."

The potential of the computer for handling individual student differences in learning rate, background, and aptitude is of primary interest to researchers working with computer-controlled automated teaching machines. Responsiveness to student learning behavior can be achieved by branching the student forward, laterally, or backward through subject materials primarily on the basis of his response to content questions seeded throughout the instructional program.

At the present state of development the computer-based teaching machine branches for the following reasons:

- a. Characteristics of student responses --the promptness and/or definitiveness of his reply.
- b. Nature of response--was it right or wrong, what specific errors were committed by the student?
- c. History of the student's learning behavior--his previous response pattern, problem areas, and reading rate.
- d. Relevant student personal data--his IQ, sex, personality, aptitudes.
- e. Nature of subject matter.
- f. Degree of student motivation.
- g. Student-generated requests for re-routing.

The only type of control unit which provides the necessary flexibility for branching is the digital computer, because the computer is the only instrument capable of

determining the item sequence and knowledge of results to be presented to the student as well as carrying out the bookkeeping activities upon which such determinations are based.

Future plans include the establishment of typewriter stations remote from the central computer system. This would permit students located in a wide geographic area to be linked into one network via leased telephone lines, which are called teleprocessing. Also contemplated is a plan for loading standardized paper-and-pencil tests (aptitude, interest, achievement) into the computer to be administered to each student at an appropriate time in the program. These test profiles could be easily used by the main executive routine in the computer to branch the student through the course in a manner best suited to his interest and ability patterns.

3. An Information Bank Aiding in the Diagnosis of Student Learning Problems and the Prescription of Appropriate Teaching Strategies

A facility for the research and development of a complete educational system that would provide optimal learning conditions has been in use at the System Development Corporation for research. This facility, designated CLASS (for Computer-based Laboratory for Automated School Systems), is a part of the large, general-purpose Systems Simulation Research Laboratory using a Philco S-2000 computer as the central control mechanism (Coulson, 1962).

CLASS permits simultaneous automated instruction of twenty students, each of whom receives an individualized sequence of instructional materials adapted to his particular needs, or learns in a group mode of instruction mediated by the teacher or computer.

To date, the research in CLASS has shown that teachers can conveniently store evaluative data on different teaching strategies designed to meet typical learning problems; it is only a matter of time before a finite number of solutions can be defined for the finite number of learning problems that students can generate in response to specific curriculum materials and instructional program. Five years of these data would yield a potential source of information for identifying: (a) patterns of learning behavior, (b) significant teaching strategies, and (c) simulation material for preparing new teachers. The data bank can lead to a new pragmatic approach to building a science of instruction rather than a science of learning.

Automating the School Library

Information retrieval (IR) is concerned with the recovery of stored information upon command. By pairing the intelligence of the human inquirer with the reliability and speed of the computer, the IR system adapted to educational situations will eventually be capable of acquiring, indexing, abstracting, storing, retrieving, and disseminating current educational information for the student and for the educator.

In addition to the library retrieval function and the automatic abstracting and indexing of document content, an additional major part of the IR system involves the input of the large amount of information to be searched. With the ongoing transcription of foreign technical articles for automatic translation and the pioneering work of storage

and retrieval centers, such as at Western Reserve University (Kent, 1963), a large volume of scientific texts is already on microfilm. But until optical scanners capable of reading printed text are fully developed, the problem of automatically gathering and simplifying stored textual information remains a major one for the public school.

Computer Simulation for Administrative Decision-Making

With the advent of the digital computer, simulation techniques have been used for purposes other than instruction. Computer simulation for effecting the analysis of an operational man-machine system and aiding the development of an advanced system design, has proved to be productive. A computerized model of an existing automated electric power plant built to alert employees to system malfunctioning, and a model of the queuing characteristics of customers in an airline ticket office developed by United Airlines for advanced planning purposes are two examples of this type of simulation. The complexity and detail with which the system can be simulated and the variety of techniques used to study, manipulate, and alter the system in order to achieve some new objectives or to monitor ongoing functions were not possible before computers came into use.

For analysis purposes, simulation has all the traditional advantages of the laboratory over contextual or field research. Whenever a real system is too large for observation, a laboratory simulation can be used. In a sense, simulation enables the experimenter to see "inside" the system operation because changes in the use of information are revealed by what the experimental subjects say to each other and the actions they take with the equipment. While the operations and procedures are under study, there is no interruption of ongoing activities. In addition, time may be compressed or expanded.

New simulation techniques should be of vital interest to building and planning supervisors. Much of the work in this field (as applied to educational problems) relates directly to their task of planning and designing new school facilities.

At Purdue University and the St. Louis Junior College District, simulation techniques are being used to forecast building and staff requirements under varying academic conditions. The development of a computer-operated program or model of Purdue University has come about because of the ease and simplicity of making repeated calculations, summarizations, and reports of facility requirements by years (or terms) for varying programs, course requirements, student enrollments, and types of facilities. These programs are management tools available to facilitate institutions in dealing with unique requirements, concepts, and policies.

At Purdue, the automatic assignment of students to a predetermined schedule of classes is already operational and more than 18,000 students are being scheduled to classes in less than six hours of an IBM 7090 computer. Also, in an experimental stage at Purdue is the construction of an "optimum" schedule of classes which will have simulation capabilities for operational and capital budgeting requirements, along with the development of staff, space, and student schedules. (See Chapter Two for additional details.)

Future Computer Hardware and Cost Trends

If the question were asked whether or not school districts could afford the large-capacity computer, the answer today would have to be no. But multi-processing, miniaturized large-capacity computers are on the horizon, and it is felt that the tools will become economically feasible in the next two or three years even for the small school district. The following developments are seen in future hardware trends:

1. The distinction between the computer, or the central data processor and its associated peripheral devices will become blurred. That is, storage, printers, and other devices will become a more integral part of the computer itself.
2. Vast magnetic tape files will be extensively used for all types of records.
3. The capacity of computer memory will be limitless for all practical purposes. Magnetic drums, disks and cards will probably become the main computer storage media for information retrieval systems during the next five to ten years. However, these techniques may be displaced in the interim by thin film or woven screen memories. This improvement would mean storage of from 10 to 100 billion bits--a capacity more than adequate for most educational systems.
4. Magnetic tape will increase in popularity.
5. Computer access time will commonly be measured in billionths of a second.
6. Communication between geographically separated computers will become as commonplace as voice communication between humans is today. The communication will take place via land-lines and microwave facilities.

These predictions serve to underscore the fact that computer hardware has been reduced in cost by one-fifth over the last three years, and there is every reason to believe that this reduction in cost will continue.

If computer-aided instructional systems are to be applied on any vast scale, they must be economically competitive with other systems performing similar functions. Some increase in equipment costs can be justified by improved teaching efficiency and subsequent reduction in training time and operational waste. It seems clear that computer-based systems must approach the over-all cost of more conventional equipment if they are to be used for more than specialized military or industrial training applications.

There appear to be other avenues by which the cost of computer-based instruction might be reduced. The first is through development of special-purpose computers and associated equipment designed for specific educational applications. Such computers could be of highly simplified design, since they would need to incorporate only the storage capacity and the operating speed and flexibility necessary for one specific job.

The special-purpose computer offers the advantage of greater efficiency in a particular task. On the other hand, the inflexibility of a special-purpose computer may prevent it from serving as a basis for expanding electronic techniques to other areas. Since these computers do only a specific job, they contribute to a compartmentalized view of school operations.

APPENDIX C

DESCRIPTIONS OF STATE, REGIONAL, AND LOCAL EDUCATIONAL DATA PROCESSING PROGRAMS

The 27 institutions described here were selected to represent a broad cross-section of types of implementation (hardware sophistication and size) and variety in population served (political relationship and size). The implementation ranges from multi-computer configurations with million-dollar annual budgets to a center with no equipment whose annual budget of a few hundred dollars pays for usage of a small installation in a nearby community. Population served ranges from a state serving 1,600 school districts to a school district with only 7,000 pupils.

Both aspects are used in the accompanying table to display for reference the selected institutions. These institutions are represented by number which can be decoded by reference to the following list of institutions. This arrangement is intended to enable the reader to identify and locate rapidly those institutions whose characteristics most interest him.

The data presented here have been volunteered in all cases by individuals currently familiar with the status of data processing in the institution reported. In no case is such data older than August 1964, although for some institutions financial data were available only for a prior fiscal year.

In many cases, the reader might well ask why a particular system or institution is mentioned when there are many others very similar which could have been. The answer must be found in the modest intention of this appendix: To sample, to suggest, to provide specific leads for further inquiry. The authors of this report had reluctantly to omit citation of many outstanding data processing systems, descriptions of which would have duplicated others to no purpose appropriate to this report.

This section of the appendix not only reveals the great diversity in problems and the great diversity in solutions but also reveals many significant common factors.

Comparability of system data is a relative matter, and the reader should know that most of the sources of this data provided descriptions largely in their own words. Many of the variables involved are subject to local or idiosyncratic definition. Some may have been affected by the translation--the attempt to provide the cohesion of a common format. A few variables have undergone some hardening of definition in the course of the data gathering. It is hoped that the presentation of a few definitions here will not mislead the reader into assuming more comparability than warranted but rather will stimulate him to go to the source for greater detail than is practical for a concise summary of this kind.

The organization budget is included as a measure of the size of the institution and to provide a basis for meaningful comparisons of the other financial data. It should represent expenditures from current income only (including debt retirement) and should not include funds from sale of bonds or other increase in indebtedness. Local budgets include state aid and federal funds, but state budgets do not usually include federal funds unless so noted.

Hardware is meant to include all equipment which encodes or processes data from machine sensible documents. Not included are forms handling equipment, bursters, decollators, bundle tying machines, paper cutters, and printing presses. Nor are typewriters included unless especially obtained as input to character recognition systems.

Hardware owned is not meant to include items not ordinarily capitalized and thus does not include control panels for leased machines.

Manufacturers are indicated parenthetically by abbreviation and appropriate model number in the text as follows:

B--Burroughs Corporation
CDC--Control Data Corporation
GE--General Electric Corporation
H--Minneapolis Honeywell Regulator Company
IBM--International Business Machines Corporation
NCR--National Cash Register Company
RCA--Radio Corporation of America
U--Univac Division of Sperry Rand Corporation

The institutions selected were chosen in part to represent a variety of geographic regions, from Washington to Florida and from California to Massachusetts (not forgetting Alaska and Hawaii). Obviously, it must not be inferred that data processing institutions are spaced far apart. Surveys of several states show the contrary. Three recent surveys by state departments of education are those of Ohio, Florida, and Washington. The reader in need of further examples might also consult Data Processing Systems by Luton Reed, who presents some statistics for 165 institutions.

When we try to look at people, hardware, software, and money as applied to data processing for public education, it is apparent that the result does not stand still for a portrait. The best we have done to date is to take some snapshots. Under appropriate auspices, one can see the utility of publishing every year or two a more comprehensive directory. It is hoped that this selective collection of sample descriptions may provide the nucleus of such an effort. To such end all those capable of correcting and augmenting this collection are urged to cooperate by corresponding with the authors of the present report.

TABLE II

**INSTITUTIONS BY SIZE OF EQUIPMENT CONFIGURATION
VERSUS POPULATION SERVED**

Size of Hardware Configuration Used

Political relationship and size of population served	Medium, large or multiple computer sys- tem used sub- stantially	Small, com- puter in-house, little out-of- house usage	No computer in-house, punched card oriented
State departments of education	13, 15	8, 22	11, 14, 19
Regional service centers	21	6	5
Counties	7	17	12, 16
Very large districts (100,000 pupils or more)	9	3	10, 14
Large districts (30,000 to less than 100,000)	18	24	26
Medium districts (10,000 to less than 30,000)		23	1, 2, 4
Small districts (less than 10,000)		25	20, 27

The entries in the above table represent institutions which may be identified by reference to the next table.

TABLE III

REFERENCE NUMBER AND LOCATION OF EDUCATIONAL INSTITUTION

1. Anchorage, Alaska
2. Ann Arbor, Michigan
3. Baltimore, Maryland
4. Bellevue, Washington
5. Board of Cooperative Educational Services (BOCES) for Cayuga County, New York
6. Board of Cooperative Educational Services, Westchester County, New York
7. Broward County, Florida
8. California, State Department of Education
9. Chicago, Illinois
10. Cleveland, Ohio
11. Connecticut, State Department of Education
12. Dougherty County, Georgia
13. Florida, State Department of Education
14. Hawaii, State Department of Education
15. Iowa Educational Information Center
16. Jefferson County, Colorado
17. Jefferson County, Kentucky
18. Los Angeles (Junior College District), California
19. Massachusetts, State Department of Education
20. Monroeville (Gateway Union School District), Pennsylvania
21. New England Education Data Systems (NEEDS), Cambridge, Massachusetts
22. New York, University of the State of New York, Education Department
23. Palo Alto, California
24. Rochester, New York
25. Shaker Heights, Ohio
26. Tulsa, Oklahoma
27. Ventura, California

1. Anchorage Independent School District

Anchorage, Alaska

18,000 pupils, K-12 and community college.

Punched card equipment acquired 1960.

Approximate budgeted expenditures for fiscal 1965:

District:	\$13,000,000
Data processing:	54,000
Hardware owned:	none

Anchorage has a punched card machine installation (IBM Series 50) which is thus far used primarily for business office and student accounting applications. A local service bureau with a computer (IBM-1620) is being utilized for class scheduling. The staff of four includes a data processing supervisor, tab operator, and two keypunch operators. The Controller, Jerry N. Waddell, is responsible for systems planning, development, and operations, and reports to the Assistant Superintendent for Administration, Don E. Fridley. The Superintendent is Don M. Dafoe.

Plans are now being coordinated with the State of Alaska for a program of staff accounting, with directory information being processed first, as a tie-in to certification, payroll, etc. Tremendous growth in data processing services is expected by the administration.

2. Public Schools of the City of Ann Arbor

Ann Arbor, Michigan

15,000 pupils, K-12. Punched card equipment acquired 1962.

Budgeted expenditures for fiscal 1964:

District:	\$9,197,925
Data Center:	40,000
Hardware rental and maintenance:	15,000
Hardware owned:	none

Ann Arbor's machine installation includes a calculating punch (IBM-602), an accounting machine (IBM-402), reproducer, collator, interpreter, sorter, keypunch, and verifier. One high school also has a document writer (IBM-826) with a keypunch and sorter. Principal applications are payroll, accounts payable, accounts receivable, financial statistics, census, scheduling, grade reporting and cumulative records. The high school equipment is used in attendance accounting.

The staff of three in the Data Center are led by David Classon, Supervisor of Data Processing, who reports through Gerald Neff, Assistant Superintendent, to Jack Elzay, Superintendent.

3. Baltimore City Public Schools

Baltimore, Maryland

196,000 pupils, K-12, 2,100 junior college students.

Acquired punched card equipment in 1928; computer configuration in 1964.

Approximate budgeted expenditures for fiscal 1965:

District:	\$105,000,000
Data Processing Center (excluding testing):	154,000
Hardware rental and maintenance:	55,000
Hardware owned:	471,000

The Baltimore Schools have a basic punched card machine installation as support for a computer (IBM-1401 16K) with four tape drives and two disc drives. The basic equipment consists of an accounting machine (IBM-407), two collators, reproducers, interpreter, sorter, keypunches and verifier. The junior college also has a computer (IBM-1620).

The Data Processing Division is under the immediate supervision of the Director of Research, Orlando F. Furno. Edward W. Riedel is Special Assistant to the Director and Data Processing Manager; Carroll Lloyd is Acting Head of Systems and Programming Procedures; Martin H. Raila is concerned with Systems Analysis Procedures. The staff involved in data processing and systems work includes 13 persons in the Data Center proper and six persons in systems and programming work.

The Data Processing Center is used for instruction in computer programming, computer operation, computer repair, and for both secondary and adult education classes. It is also used for instruction in mathematics, science, and business education. The Data Processing Center's services include such applications as inventory control, payroll and cost analyses, report cards, pupil attendance, test scoring, and budget preparation.

4. Bellevue Public Schools (District Number 405)

Bellevue, Washington

17,600 pupils, K-12. Began punched card operations in 1960.

Approximate budgeted expenditures for fiscal 1965:

District:	\$9,500,000
Data Center:	30,000
Hardware rental and maintenance:	12,000
Hardware owned:	1,000

The Data Center has an accounting machine (IBM-402), reproducer, collator, interpreter, two sorters, keypunch, and verifier. This equipment is used to serve ten secondary schools, 19 elementary schools, business and administrative divisions and such special areas as testing.

Services include all schools: (1) Federal aid survey (PL 874), student accident reports, student residence zones, testing, guidance, physical fitness survey of students, class lists, physical education records, attendance and research, textbooks list. (2) Junior and senior high school student class lists, scheduling, report cards, failure and incomplete lists, address files, GPA computations, GPA lists alphabetical and by rank, and student body accounting. (3) In the business division, payroll time sheets, computing of payroll, payroll reports for certificated and classified, FICA reports, withholding statements, labor distribution, job cost, inventory, employee monthly audits, employee ledger posting, address labels, industrial arts and textbook order forms. (4) Other areas: personnel accounting, summer school scheduling, class lists and bus routes and stops. At the present time, system analysis is being done by staff to integrate personnel and payroll departments. Also, system analysis is presently directed towards purchasing, accounts payable, and cost accounting.

A staff of three assist Alanson T. Powell, Business Manager, who reports to Myron Ernst, Superintendent.

5. Board of Cooperative Educational Services for Cayuga County

Auburn, New York

7,000 pupils, K-12, in six central school districts.

Acquired punched card equipment in 1964.

Approximate budgeted expenditures for fiscal 1965:

BOCES:	\$300,000
Data Processing:	19,000
Hardware owned:	none

Cayuga County BOCES leases an accounting machine (IBM-402) supported by a reproducer (IBM-514), a sorter, and (located in the participating schools) four keypunches. The immediate task is the service of six central districts, but it is hoped that in the spring costs will be reduced by renting equipment to other nearby city districts.

The center presently has a staff of one, the supervising operator, Frederick Scholl, who reports to Raymond T. Sant, District Superintendent. Two part-time and two full-time keypunch operators are employed by the participating school districts.

The center will be used first for attendance accounting and the production of report cards. It will also be used for instruction in business education.

6. Board of Cooperative Educational Services, Second Supervisory District,
Westchester County

Port Chester, New York

40,000 pupils, K-12; 26 districts.

Began punched card operations in 1962; computer in 1964.

Approximate budgeted expenditures for fiscal 1965:

Not available

Hardware owned:

none

Westchester BOCES-2 has a recently installed computer (Univac-1004) supported by a small (two keypunch) installation. Service is provided to participating districts in a number of areas such as fiscal accounting, census, scheduling, attendance, report cards and test scoring. Beginning in 1964-1965, a two-year senior high curriculum in data processing is being offered, with courses involving laboratory use of equipment.

BOCES was organized to help cooperating school districts obtain services not readily or economically available to small districts. Data processing is a relatively new service; previous services include a shared teacher program in such areas as art and music and a centralized vocational and special education program.

In data processing, the staff of six persons is led by Robert Brophy, Manager, who reports to Bernard L. Bryan, District Superintendent.

7. Broward County Board of Public Instruction

Fort Lauderdale, Florida

81,000 pupils, K-14. Began punched card operations in 1959; computer in 1963.

Approximate budgeted expenditures for fiscal 1965:

Board of Public Instruction: \$36,500,000

Data Processing: 250,000

Hardware rental and maintenance: 165,000

Hardware owned: none

Broward County BPI has two computers (IBM-1620 20K, IBM-1401 8K column binary) with two magnetic tape drives and two magnetic disc drives. There is telephonic data transmission equipment connecting the Computer Center at the Junior College with the BPI office. The complete line of supporting equipment includes two accounting machines (IBM-407, 402) and 27 keypunches. Keypunches are installed in 19 schools; sorters, in eight.

Pupil record applications are of special interest: student schedules, teacher schedules, class rolls, locator cards, welfare and attendance cards, library labels, grade audit sheets, report cards, class loads, permanent record

labels, grade point average reports, grade distributions, locker assignments, bus rosters, assembly seat assignments, and graduation lists. Magnetic disc pack procedures for permanent records and for assigning students to course sections are being tested.

In addition to pupil records, substantial service is offered in eight areas: payroll and personnel, accounting, testing, pupil accounting, instruction (data processing and computer technology), budget analysis and control, data transmission, and system design. The Center has cooperated in development work on significant innovations for Nova High School and for Florida Atlantic University.

A central staff of 16, headed by the Director of Data Processing, works closely with the junior college data processing laboratory staff of five and with the operators at 19 schools. Included are two programmers, a systems analyst and a communications specialist. The Director, William J. English, reports to Myron L. Ashmore, Superintendent.

8. California State Department of Education

Sacramento, California

4,400,000 pupils in 1,600 districts.

Acquired card equipment in 1946, computer in 1962.

Approximate budgeted expenditures for fiscal 1965:

From all sources:	\$3,500,000,000
From state income:	1,385,000,000
Bureau of Educational Research:	300,000
Hardware rental and maintenance:	22,000
Hardware owned:	500,000

The Bureau has a computer (RCA-301 20K) with six magnetic tape drives, printer, card reader and punch. Support is provided by a basic machine installation including a tabulator (IBM-402). The unit serves the entire Department in all phases of its data processing needs. The staff consists of a consultant in education research, data processing manager, ATMS II supervisor, four programmers, console operator, two tab operators, and ten keypunch operators. Consultant Peter J. Tashnovian is responsible for its operation.

The installation is responsible for the computation of all school apportionments, amounting to \$850 million in 1964-65; the analysis of state test data for 800,000 pupils; analysis of financial transactions of school districts; textbook distribution; surveys of school enrollments and salaries; school lunch and surplus property programs; vocational education programs; property accounting, and a large and varied number of special projects and services.

9. City of Chicago Public Schools

Chicago, Illinois

600,000 pupils, K-16. Acquired card equipment about 1935.

Acquired computer in 1963.

Approximate budgeted expenditures for fiscal 1965:

District:	\$325,000,000
Bureau of Data Processing:	1,100,000
Hardware rental and maintenance:	400,000
Hardware owned:	none

The Bureau of Data Processing has an optical character-recognition data converter with attached computer (SDS-910 8K) and two tape drives. This equipment was designed to read both typewritten copy and computer-printed copy. The magnetic tapes from the data converter are expected to constitute the principal data input to the Bureau's computer complex (IBM-7040 10K, two IBM-1401 8K, and a 1401 4K). Altogether there are 18 tape drives attached. The complete line of supporting punched card equipment includes 15 keypunches. The installation is used to implement a "Total Information Service" integrating data processing services in six areas (1) budget and finance, (2) personnel and payroll, (3) materials, (4) student accounting and scheduling, (5) computer education, and (6) research.

The staff of 83 includes 35 system analysts and programmers and is divided into four principal groups led by L. Lafave (Data Processing Education), H. Levine (Research), J. Clancy (Operations), and R. Baileys (Systems). J. Quinn, Assistant Director, Administration, reports to Stanley R. Patton, Director of Data Processing, who reports to Benjamin C. Willis, General Superintendent of Schools.

10. Cleveland City School District

Cleveland, Ohio

154,000 pupils, K-12. Acquired card equipment in 1962.

Approximate budgeted expenditures for fiscal 1964:

District:	\$64,000,000
Outside data services:	9,000
Data Center:	40,000
Hardware rental and maintenance:	15,000
Hardware owned:	none

Cleveland has two data processing installations, one under the control of the Superintendent and one under the control of the Clerk-Treasurer (reporting directly to the Board). A small computer is now on order and a larger computer planned for the future is expected to serve all areas and thus lead to the elimination of separate installations. At present the two accounting machines (IBM-403) and supporting punched-card equipment are devoted to financial accounting, textbook ordering and distribution, certificated

personnel records, scheduling, grade reporting, and such by-products as class ranks. Scheduling is done with the help of a computer (IBM-7090), which is available through a service bureau.

A staff of three and a half assists Darien Smith, Assistant Superintendent, Personnel, who reports through A. R. Dittrick, Deputy Superintendent to Paul Briggs, Superintendent. A staff of three reports to Michael Wach, Clerk-Treasurer.

11. Connecticut State Department of Education

Hartford, Connecticut

Size and grade level of pupil population not available.

First used punched card equipment in 1961.

Approximate budgeted expenditures for public education from current income:

From all sources 1962-1963:	\$288,500,000
From state income:	102,100,000
For data processing:	22,000
For hardware rental and maintenance:	4,000
Hardware owned (one keypunch and one verifier):	3,000

The Connecticut State Department of Education has a small punched card installation, including an accounting machine (IBM-402 series 50), sorter, two keypunches, and a verifier. Service is provided for application-grant payment, registration of certificated personnel, salary studies, teacher demand, school population, physical education, and school milk and lunch. Some of these applications require use of an all alphabetic printer (IBM-407) or of a small computer (IBM-1620/1401/1440), access to which is provided by Connecticut State Technical Institute.

The staff is composed of three persons, header by Herbert Hill, Senior Tab Supervisor, who reports through Maurice Ross, Chief, Bureau of Statistics, to William J. Sanders, Commissioner.

12. Dougherty County Schools

Albany, Georgia

21,000 pupils, 1-12. Began punched card operations in 1963.

Approximate budgeted expenditures for fiscal 1965:

District:	\$6,100,000
Data Center:	35,000
Hardware rental:	15,000
Hardware owned:	none

Dougherty County has an optical scanner (IBM-1232) with attached punch, tabulator (IBM-407), reproducer, collator, sorter, and two keypunches. The equipment is used in payroll and in maintaining a file of student

registration data. The scanner is used in attendance accounting. Additional equipment in the area vocational school is used in an adult program.

A supervising operator, two keypunch operators and temporary help report to J. G. Sowell, Business Manager, who reports to J. J. Cordell, Superintendent.

13. State of Florida Department of Education

Tallahassee, Florida

1,200,000 pupils, 52,000 teachers, 67 school districts, 35 public institutions of higher education. Began punched-card operations in 1939; acquired card equipment in 1960, computer in 1962.

Approximate expenditures for public education from current income, fiscal 1964:

From all sources including local and federal:	\$496,000,000
From state income:	273,000,000
For data processing in the state department:	305,000
For hardware rental and maintenance:	130,000
Hardware owned:	394,000

The Department of Education has two computer systems (IBM-1401 8K and RCA-301 20K) with 11 magnetic tape drives supported by a seven keypunch EAM installation that includes a statistical sorter (IBM-101). The installation is used to summarize data from the local districts, to process personnel records, and to produce financial reports and reports of special education. Substantial effort has been devoted to the development of a library of programs of use to the local districts.

The staff of 36 includes L. Everett Yarbrough, Systems Consultant, Archie B. Johnston, System Consultant; Robert W. Sims, Coordinator of Systems; A. Buford Moulton, Coordinator of Data Processing. The system is under the direction of James K. Chapman, Deputy Superintendent, who reports to Thomas D. Bailey, Superintendent.

14. Hawaii State Department of Education

Honolulu, Hawaii

176,000 pupils, K-adult. Punched card equipment acquired in 1960.

Approximate budgeted expenditures from current income (1964):

From all sources:	\$59,000,000
From state income:	53,000,000
Data processing--not given but appears	140,000
Hardware rental and maintenance:	40,000
Hardware owned:	none

The Hawaii State Department of Education is unique in that it operates the local schools of the state as well as performing the usual state functions. The Office of Research, Statistics and Data Processing has two accounting machines (IBM-407) supported by two reproducers, an interpreter, a collator, two sorters, two test scoring machines, and five keypunches.

Superintendent of Public Instruction is R. Burl Yarberry. Assistant Superintendent for Research, Statistics and Data Processing is William G. Savard. Data Processing Unit Supervisor is Tad T. Nakano. Staff includes a computer programmer, four tabulating equipment operators, a key punch supervisor, seven key punch operators, a test scoring supervising clerk, and two part-time clerks.

Major application areas include: budget and appropriation accounting, staff personnel accounting, cafeteria accounting, library order processing, student master records, student scheduling (bin method), grade reporting and analysis, test scoring and analysis, institutional and educational research, and service to three other state departments for miscellaneous applications.

The department is presently using the University of Hawaii's computer (IBM 1401, with tapes), to process and analyze pupil test data. It is also used for research projects and personnel applications. Programming and processing includes a portion of personnel accounting on the 1401. Planning for a computer-based total information system has begun.

15. Iowa Educational Information Center

Iowa City, Iowa

620,000 pupils, K-12. 2,000 school districts.

Project "UPDATE" began in 1962. Services under present organizational structure began January 1, 1964.

Approximate budgeted expenditures for fiscal 1965:

Information Center:	\$220,000
Computer and scanner utilization:	150,000
Hardware owned:	none

The Information Center is a joint venture of the State Department of Public Instruction and the University of Iowa and is funded by an eighteen-month grant from the U. S. Office of Education for almost \$.25 million and a five-year grant from the Ford Foundation for \$.75 million. The Center serves public education in the entire state and is serving some out-of-state school districts in three principal areas: educational specifications, systems and procedures, and field operations. In the latter area it is concerned with data gathering, system design and maintenance, and dissemination of information.

Actual processing, however, is done through the Measurement Research Center on its optical scanner and two computers (CDC-160 and IBM-1460). Substantial work is also done at the University Computing Center (IBM-7040). The State Department of Public Instruction maintains at Des Moines a punched card installation for preparing input both to the Information Center and to the open shop State Computer Center under the administration of the State Controller.

Applications exploit the entire range of educational data using the most sophisticated techniques and hardware. Computer class sectioning has already been applied to 60 high schools. Magnetic tapes are being prepared with unit records of every child in the state testing program. The Center is also conducting a program of instruction for doctoral candidates in education who wish to specialize in data processing.

The staff of 19 is led by Robert Marker, Director; Ralph Van Dusseldorp, Associate Director; Bruce Alcorn, Program Coordinator; Peter McGraw, Assistant Director for Program Development. The Department of Public Instruction's Data Center at Des Moines is under the direction of Marvin Ingle. The State Computer Center is under the administration of Harold Gandy, Controller.

16. Jefferson County School District R-1

Jefferson County, Colorado

50,000 pupils, K-12 plus special education and adult education.

Acquired card equipment in 1959.

Approximate budgeted expenditures for calendar 1965:

District:	\$27,000,000
Information services (not including testing):	70,000
Hardware rental and maintenance:	26,000
Hardware owned:	none

Jefferson County School District R-1 has a unit-record installation consisting of two accounting machines (IBM-403), an interpreter (IBM-557) and a complete line of supporting punched card equipment. It is used equally for financial accounting and student accounting. The staff of seven includes four punch operators, two tab operators, and a data processing supervisor. Supervisor Murry C. Grigsby reports to the Director of Research, Edward Brainard, who in turn reports to the Superintendent of Schools, Forbes Bottomly.

The unit record equipment is used for instruction in business education. Computer time is "begged, borrowed, and bought" for instruction in mathematics and science. Business services include payroll, accounts payable, directories, property accounting, and label addressing. Educational services include student scheduling (four schools have been scheduled for 1964-65 on an IBM-1620), attendance reporting, grade reporting, permanent record labels, certificated personnel statistics, and some local test analysis.

17. Jefferson County Public Schools

Louisville, Kentucky

67,000 pupils, 1-12. Acquired computer 1960.

Budgeted expenditures for fiscal 1965:

District:	\$25,000,000
Data processing:	60,000

Hardware:	\$ 25,000
Hardware owned:	none

The Jefferson County office serves the schools in the county system but does not serve independent schools. Louisville has its own installation. The county equipment includes a computer (NCR-390) with on-line keypunch, type-writer, paper tape reader and punch, and an accounting machine (NCR-31) with additional paper tape output. Off-line support includes two keypunches and a sorter. The equipment not only handles paper tape and punched cards but also NCR ledger cards storing up to 200 characters in magnetic strips.

Principal applications are census, budget, purchase order control, payroll, attendance accounting and professional personnel records. There is a staff of four and a half in the business area and three in the census area devoted to data processing, all of whom report to E. Grayson, Associate Superintendent for Accounting and Finance, who reports to Richard Van Hoose, Superintendent.

18. Los Angeles City Junior College District

Los Angeles, California

70,600 students, grades 13-14. Acquired punched-card equipment in 1949. Acquired computer in 1957.

Budgeted expenditures for fiscal 1964:

District:	\$23,000,000
Hardware rental and maintenance:	100,000
Hardware owned:	540,000

There are seven colleges in the district. Six have EAM units assigned to the admissions offices which are used primarily for administrative work. However, instructional demonstrations are given from time to time during the semester. These units are staffed by a supervisor, from one to four machine operators, and a keypunch operator. This staff is also responsible for the administrative work done on the computers.

Eight small computers (seven IBM-1620 and one CDC G-15) are installed at six of the colleges. These are used primarily for instruction in mathematics, business, and electronics technician training. The computers are staffed by members of the instructional departments involved and by various lab assistants. Some administrative work is done by the staffs of the EAM units.

All seven colleges are directed by the Assistant Superintendent, Walter Coultas, who reports to the Associate Superintendent of College and Adult Education, T. Stanley Warburton, who in turn reports to the Superintendent of Schools, Jack P. Crowther. A Data Processing Coordinator for the seven colleges, Lloyd Cadbury, reports to Coultas.

19. The Commonwealth of Massachusetts Department of Education

Boston, Massachusetts

926,000 pupils, K-12; 38,800 teachers; 387 districts.

Acquired card equipment in 1960.

Approximate expenditures for public education from current income, fiscal 1963:

From all sources:	\$401,500,000
From state income:	97,000,000
Division of Research and Statistics:	100,000
Hardware rental:	20,000
Hardware owned:	13,500

The Division has a tabulator (IBM-407), supported by a reproducer, collator, interpreter, sorter, four keypunches, and a verifier. The staff of five assists Glenn Myers, Supervisor, who reports to Raymond S. Dower, Jr., Director of the Division of Research and Statistics. Owen B. Kiernan is Commissioner of Education.

The equipment is primarily used for the preparation of statistics under Title X of the National Defense Education Act. All divisions of the Department of Education are serviced by the data center. Considerable use is made of computer installations in the Boston area to develop programs for future use on a department computer. The Division has also been of service to local school systems, helping them with pupil attendance and high school scheduling procedures.

20. Gateway Union School District

Monroeville, Pennsylvania

7,400 pupils, 1-12. Began punched card operations in 1962.

Approximate budgeted expenditures fiscal 1965:

District:	\$4,500,000
Data processing services:	2,000
Hardware rental:	none
Hardware owned:	none

Gateway uses equipment owned by Allegheny County, housed at Forbes Trail School and used primarily in an area vocational training program. Scheduling, report cards, and attendance accounting are present applications. Consideration is being given to financial accounting.

The combined efforts of county personnel, students, graduates of the vocational program, and regular clerical employees are used as needed under the coordination of Eugene B. Yarnell, High School Principal, who reports to Carl Newman, Superintendent.

21. New England Education Data Systems

Cambridge, Massachusetts

50,000 pupils, in 23 grade school and college systems. For several years, developmental work and experimental service has been offered using borrowed hardware; in 1963 a computer was acquired and full services were offered from a central installation.

Approximate budgeted expenditures for fiscal year 1964-1965:

From all sources:*	over	\$1,000,000
Central operation:*		371,000
Hardware rental and maintenance (central):		55,000
Hardware owned:		none

*Larger figure includes credits to member districts for services, machine rental, space, etc. Initial support includes contributions from the Ford Foundation.

NEEDS uses large computers (IBM-7090) at Harvard and the Massachusetts Institute of Technology and has its own computer (IBM-1401 8K column binary) with four magnetic tape drives and two disc drives. A complete punched card installation includes an accounting machine (IBM-407) and six keypunches. There are also three satellite punched card installations in member districts. Newton, Massachusetts, and Manchester, Connecticut, have installations including a tabulator (IBM-407) and Danvers, Massachusetts, has a smaller installation (IBM-402).

A complete range of data processing services is offered to members, especially class sectioning and computerized assistance in master schedule building. The desired characteristics and potential uses of the data bank created as a by-product of the system are being studied by John B. Carroll, Professor of Education, Harvard.

A staff of 20, plus 13 part-time students, is needed for administration, system development, and programming. Allan B. Ellis is in charge of basic research and formal instruction. Victor Oppenheimer is Acting Director of Operations. Both report to Gil Boyer, Administrator. The board of directors represents six state departments of education, member universities, and the New England School Development Council.

22. University of the State of New York, State Education Department

Albany, New York

4,200,000 pupils, K-16, in 1,300 school systems.

Began card operations about 1955; acquired computer 1964.

Approximate budgeted expenditures from current (1964) income:

From all sources including local and federal:	\$3,300,000,000
From state income:	1,336,000,000
For Bureau of Electronic Data Processing:	600,000

For hardware rental and maintenance:	\$ 170,000
Hardware owned:	none

The Bureau of Electronic Data Processing has a computer (GE-225 8K) with six magnetic tape drives and an optical scanner (Digitek). A large EAM installation, including several accounting machines (IBM-407), calculating punches and a keypunch-verifying section of about 20 machines, is being cut back somewhat with the installation of the computer. The EAM equipment will continue many of the present applications in research and statistics, such as financial, attendance and vocational rehabilitation reports. First applications on the computer are the state scholarship program and the state registration of certain professionals such as certified public accountants, nurses and teachers.

The Bureau's staff of about 45, with two system analysts and six programmers, is headed by Ruth Callahan, Director of Data Processing, who reports through Ewald Nyquist, Associate Commissioner, to James E. Allen, Commissioner.

23. Palo Alto Unified School District

Palo Alto, California

15,000 pupils, K-12. Acquired card equipment in 1958, computer in 1963. Approximate budgeted expenditures for fiscal 1965:

District:	\$11,000,000
Information services (including group testing)	140,000
Hardware rental and maintenance:	33,000
Hardware owned:	130,000

Palo Alto has an optical scanning machine (Franklin Chang) and a basic EAM installation as support for a small computer (IBM-1620) with magnetic disc storage and line printer. It is used primarily for instruction, for pupil data processing, and for research. The staff of 12 persons includes a system analyst, two project specialists, two programmers, a group testing supervisor, a computer center manager, and a second shift supervisor. The Director of Information Services, Murray Tondow, reports to the Superintendent of Schools, Harold Santee.

The computer is used for instruction in programming, for both secondary and adult classes, and for instruction in mathematics, science, and business education. Educational services include pupil scheduling, report cards, attendance system (including weekly reports to counselors), posting to transcripts, test scoring and data analysis, parent name and address label printing, personnel records, assistance with budget preparation and a variety of specialized services.

A district-wide coordinating committee assists in establishing policies for system operation and in implementing new applications. Considerable use is made of available files for research and evaluation of the district's educational program. Occasional use is made out-of-house Honeywell-800, IBM-7090, Burroughs-200, and CDC-1604.

24. Rochester City School District

Rochester, New York

46,000 pupils, K-12. Acquired card equipment in July 1959. Computer will be installed in mid-October 1964.

Approximate budgeted expenditures for fiscal 1965:

District:	\$31,000,000
Data center budget:	115,000
Hardware rental:	54,000
Hardware owned:	none

Rochester's basic EAM installation is used primarily for financial and student accounting. Also, at one of the high schools, IBM series 50 equipment is installed for instruction. An optical reader (IBM-1230) has been installed since March 1964, primarily for test scoring, but is also used in other applications. A Burroughs B-263 computer will be installed in mid-October 1964 to replace two 407's and a 602.

The staff of nine is headed by Data Processing Supervisor, Carl S. Florino. Paul Reason, Assistant Superintendent, in charge of Business Affairs reports to Herman Goldberg, Superintendent.

The data processing equipment is used for financial accounting (payroll, inventory, budget), student accounting (scheduling, report cards), and many other services.

25. Shaker Heights City School District

Shaker Heights, Ohio

7,600 pupils, K-12. Card equipment installed in 1960; computer in 1965.

Approximate budgeted expenditures for fiscal 1964:

District:	\$6,700,000
Data Center:	46,000
Hardware rental:	25,000
Hardware owned:	none

Shaker Heights is installing a computer (Univac-1004) in 1964-65. Previously installed equipment includes an optical scanning punch (U-5340), an accounting machine (U-6090, Model 3), and supporting punched card machines. The computer will be leased through Boothe Leasing Corporation.

The initial applications were devoted exclusively to educational services, with the intention of proceeding to business applications at a later date. It is anticipated that the full range of educational and business procedures will eventually be converted. Plans are under way to institute instruction in data processing at the high school level.

Applications to date include student information services; report cards, attendance, cumulative records in the elementary school, test scoring and tabulating, student scheduling (primarily to printing of student schedules), master lists, class lists, employee absence, cumulative sick leave, substitute payroll, miscellaneous personnel information, including salary certification, and budget control reports.

The staff includes three operators and a data processing supervisor. The installation is under the direct supervision of William Cunningham, Assistant to the Superintendent, who reports to the Superintendent of Schools, Donald G. Emery.

26. Independent School District #1, Tulsa County, Oklahoma

Tulsa, Oklahoma

75,000 pupils, K-12. Began punched card operations December 1963.

Approximate expenditures in fiscal 1964:

Data processing department:	\$65,000
Hardware rental:	23,000
Hardware owned:	none

Tulsa has acquired an optical scanner (IBM-1230) with punch. The installation includes a calculating punch (IBM-604), a tabulator (IBM-407), and a complete supporting EAM installation with three keypunches. Initial applications have been financial accounting (especially cafeteria and payroll for 3,500 employees), research, analysis and summarization of test data, census, and attendance.

The staff of eight include J.O. Brown, Manager of the Data Processing Department, reporting to H. H. Edwards, Director of Attendance and Census, who reports through Cecil Benson, Assistant Superintendent, to Charles Mason, Superintendent.

27. Ventura Union High School District

Ventura, California

6,500 pupils, grades 7-12. Acquired punched card equipment in 1958.

Budgeted expenditures for 1964-1965:

District:	\$5,200,000
Outside computer services: less than	300
Data Center:	41,200
Hardware rental:	17,000
Hardware owned:	none

The Data Center has an accounting machine (IBM-407) supported by a reproducer, interpreter, collator, sorter, and two keypunches. In order to accomplish some business extensions, grade point averages and registration of students, out-of-house computers (IBM-1440, 1401, and 7044) are used during the school year. Ventura County Schools Office, using the

FAST system, scores all standardized tests. All other testing processes (labels, distributions, etc.) are accomplished in the District Data Center.

Student applications: registration, attendance accounting, roll books, grade reporting, testing, test reporting, transcripts, student voting, student body locker cards, athletic classification, master program building, curriculum studies, grouping studies, and parent communications of various types.

Business applications: appropriation ledgers, general ledgers, warehouse issue and control, accounts payable, warrants, pay-roll warrants, state retirement, social security, W-2 reporting, budget and cafeteria reporting.

The high school business education department gives some instruction for business students. Each school has representatives on a district-wide data processing council. Every other year a handbook is published.

The staff includes a tab supervisor and two keypunch machine operators. These are supported by the district's Head of Accounting, Robert Baker, responsible for basic operation and business applications, who reports to Ralph Raitt, Business Manager. Robert E. Rolens, Director of Research and Curriculum Consultant is responsible for educational applications. He works with Assistant Superintendent Frank M. Gulick, Head of the Division of Educational Services. All of the above report to L. L. Jones, District Superintendent of Schools.

APPENDIX D

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